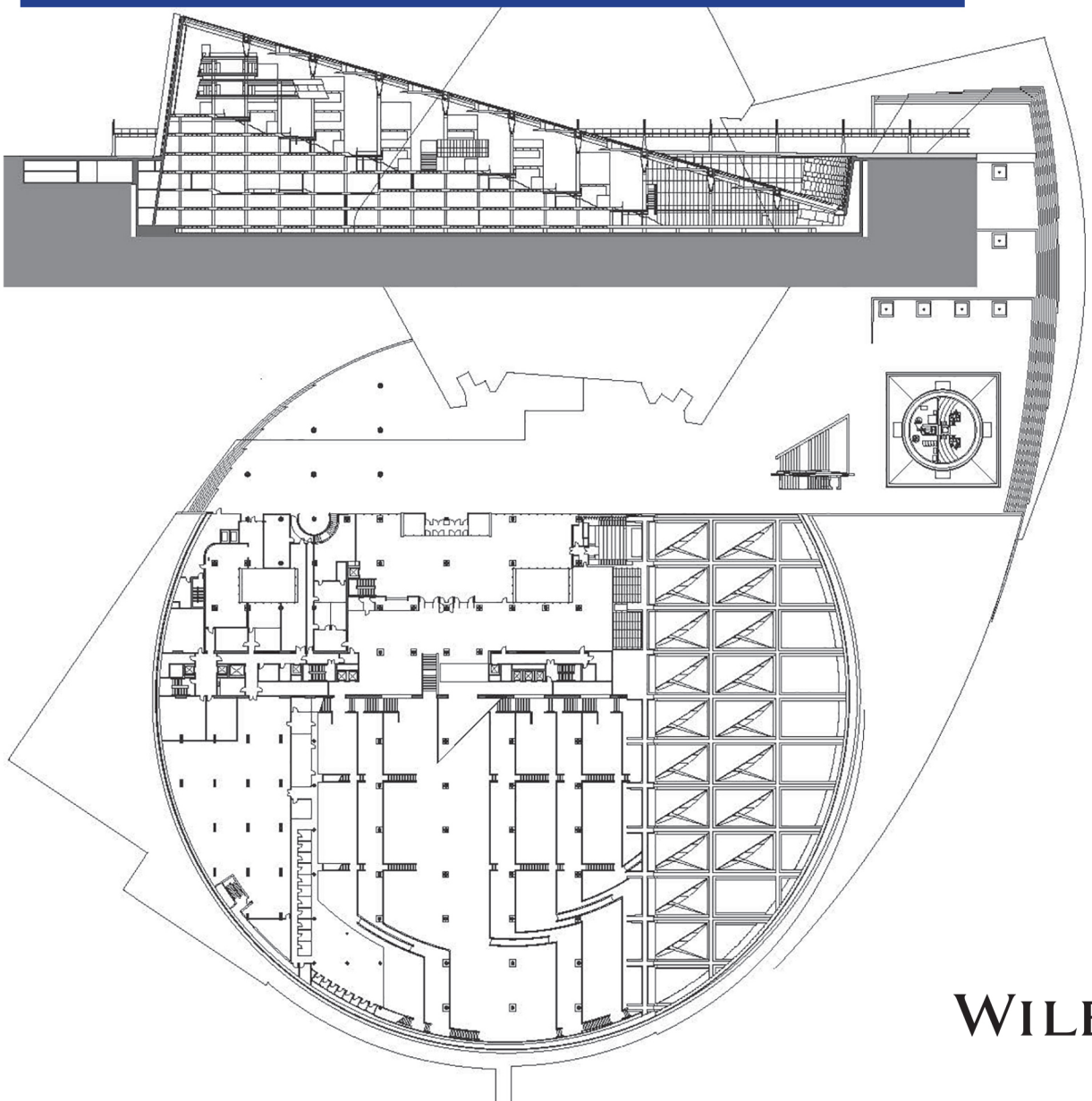
FRANCIS D.K. CHING

ARCHITECTURE

— FORM, SPACE, AND ORDER —

FIFTH EDITION



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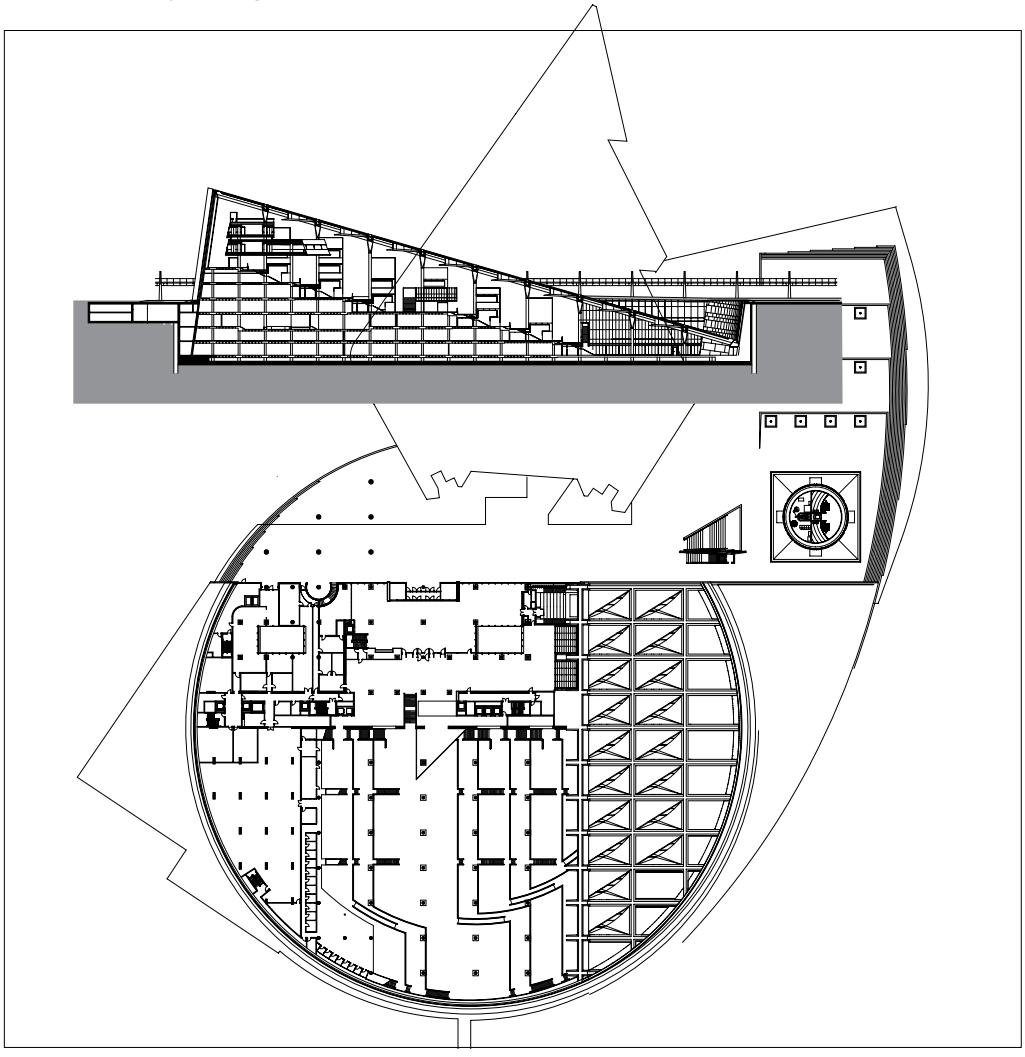

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Contents

Preface vii
Introduction ix

1 Primary Elements
Primary Elements 2
Point 4
Point Elements 5
Two Points 6
Line 8
Linear Elements 10
From Line to Plane 14
Linear Elements Defining Planes 15
Plane 18
Planar Elements 20
Volume 28
Volumetric Elements 30

2 Form
Form 34
Properties of Form 35
Shape 36
Primary Shapes 38
Circle 39
Triangle 40
Square 41
Primary Solids 42
Regular & Irregular Forms 46
Transformation of Form 52
Dimensional Transformation 54
Geometric Transformation 58
Subtractive Form 68
Subtractive & Additive Forms 71
Additive Form 72
Centralized Form 74
Linear Form 76
Radial Form 80
Clustered Form 82
Grid Form 86
Formal Collisions of Geometry 88
Circle & Square 90
Rotated Grid 94
Articulation of Form 98
Edges & Corners 100
Corners 101
Surface Articulation 106

3 Form & Space
Form & Space 118
Form & Space: Unity of Opposites 120
Form Defining Space 128
Horizontal Elements Defining Space 129
Base Plane 130
Elevated Base Plane 132
Depressed Base Plane 138
Overhead Plane 144
Vertical Elements Defining Space 154
Vertical Linear Elements 156
Single Vertical Plane 164
L-Shaped Configuration of Planes 168
L-Shaped Planes 169
Parallel Vertical Planes 174
Parallel Planes 176
U-Shaped Planes 180
Four Planes: Closure 186
Four Planes: Enlosure 190
Openings in Space-Defining Elements 194
Openings within Planes 196
Openings at Corners 198
Openings between Planes 200
Qualities of Architectural Space 202
Degree of Enclosure 204
Light 206
View 212
Ventilation 218

4 Organization
Organization of Form & Space 222
Spatial Relationships 223
Space within a Space 224
Interlocking Spaces 226
Adjacent Spaces 228
Spaces Linked by a Common Space 230
Spatial Organizations 232
Centralized Organizations 234
Linear Organizations 244
Radial Organizations 254
Clustered Organizations 260
Grid Organizations 270

CONTENTS

5 Circulation

Circulation: Movement through Space 280
Circulation Elements 281
Approach 282
Entrance 290
Configuration of the Path 304
Path-Space Relationships 318
Form of the Circulation Space 322
Stairways 326

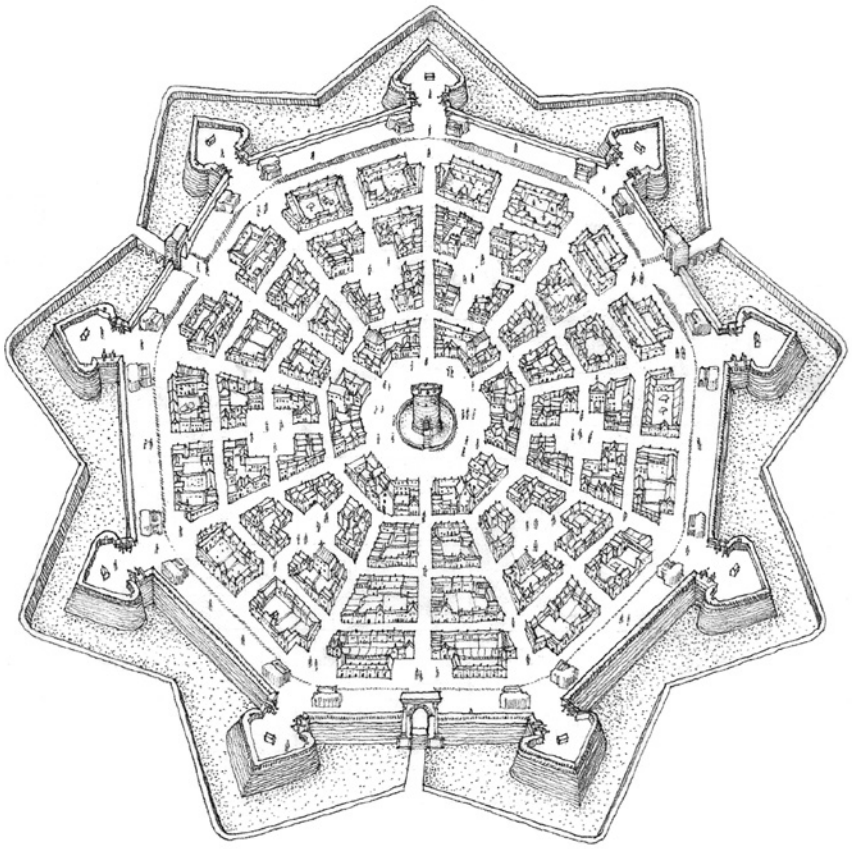
6 Proportion & Scale

Proportion & Scale 336
Material Proportions 337
Structural Proportions 338
Manufactured Proportions 340
Proportioning Systems 341
Golden Section 344
Regulating Lines 348
Classical Orders 350
Renaissance Theories 356
Modulor 360
Ken 364
Anthropometry 368
Scale 371
Visual Scale 372
Human Scale 374
A Scalar Comparison 378

7 Principles

Ordering Principles 382
Axis 384
Symmetry 392
Hierarchy 402
Datum 412
Rhythm 428
Repetition 429
Transformation 450

Conclusion 456
A Selected Bibliography 459
Glossary 461
Index of Buildings 469
Index of Designers 475
Index of Subject Matter 477



Preface

The original edition of this study introduced the student of architecture to form and space, and the principles that guide their ordering in the built environment. Form and space are the critical means of architecture comprising a design vocabulary that is both elemental and timeless. The second edition continued to be a comprehensive primer on the ways form and space are interrelated and organized in the shaping of our environment while being refined by editing the text and incorporating diagrams for greater clarity; adding selected examples of architectural works; expanding the sections on openings, stairways, and scale; and finally, by including a glossary and an index to designers. The third edition persisted in illustrating the ways the fundamental elements and principles of architectural design manifest themselves over the course of human history but added an electronic component to introduce the aspects of time and movement to the exposition of elements and principles. The fourth edition added more than two dozen contemporary examples, selected to illustrate the new forms that go beyond the timeless elements of basic statics—the columns, beams, and load-bearing walls of stable constructions that are fixed in time and space. Five more modules were added to the electronic component to animate certain design decisions regarding scale and proportion, the type of visual, often subtle judgements that designers face in the development of a project.

In this fifth edition, more recent additions to the architectural panoply illustrate how contemporary digital and building technologies have influenced the development of architectural forms and spaces—and how architectural siting and design have responded to the call for more environmentally responsible buildings.

The historical models in this book span time and cross cultural boundaries. While the juxtaposition of styles may appear to be abrupt at times, the diverse range of examples is deliberate. The collage is intended to persuade the reader to look for likenesses among seemingly unlike constructions and bring into sharper focus the critical distinctions that reflect the time and place of their making. Readers are encouraged to take note of additional examples encountered or recalled within the context of their individual experiences. As the design elements and principles become more familiar, new connections, relationships, and levels of meaning may be established.

The illustrated examples are neither exhaustive nor necessarily the prototypes for the concepts and principles discussed. Their selection merely serves to illuminate and clarify the formal and spatial ideas being explored. These seminal ideas transcend their historical context and encourage speculation: How might they be analyzed, perceived, and experienced? How might they be transformed into coherent, useful, and meaningful structures of space and enclosure? How might they be reapplied to a range of architectural problems? This manner of presentation attempts to promote a more evocative understanding of the architecture one experiences, the architecture one encounters in literature, and the architecture one imagines while designing.

ABOUT THE COMPANION WEBSITE

This book is accompanied by a companion website

www.wiley.com/go/ching/architecturefso5e

This website includes:

- Animations
- Flashcards
- Google Earth Coordinates/Downloadable Content

ACKNOWLEDGMENTS

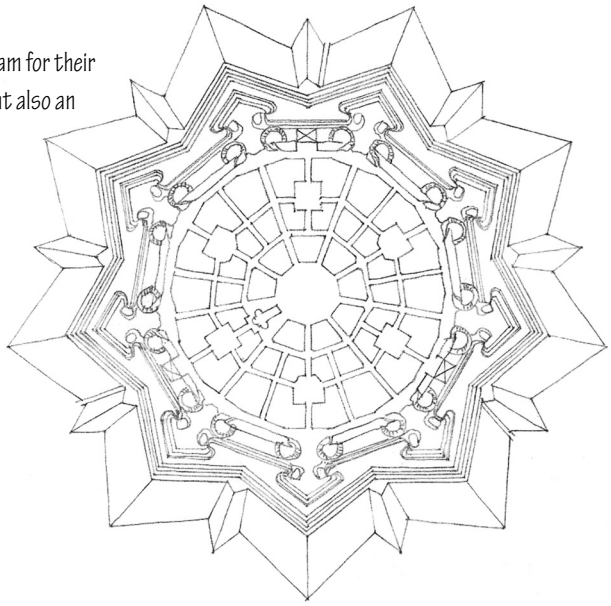
I will always be indebted to the following people for their invaluable contributions to the original edition of this work: Forrest Wilson, whose insights into the communication of design principles helped clarify the organization of the material, and whose support made its initial publication possible; James Tice, whose knowledge and understanding of architectural history and theory strengthened the development of this study; Norman Crowe, whose diligence and skill in the teaching of architecture encouraged me to pursue this work; Roger Sherwood, whose research into the organizational principles of form fostered the development of the chapter on ordering principles; Daniel Friedman, for his editing of the final copy; Diane Turner and Philip Hamp, for their assistance in researching material for the illustrations; and to the editorial and production staff at Van Nostrand Reinhold, for their exceptional support and service during the making of the first edition.

For the second edition, my appreciation extends to the many students and their teachers who have used this book over the years and offered suggestions for its improvement as a reference and tool for study and teaching. I want to especially thank the following educators for their careful critique of the first edition: L. Rudolph Barton, Laurence A. Clement, Jr., Kevin Forseth, Simon Herbert, Jan Jennings, Marjorie Kriebel, Thomas E. Steinfeld, Cheryl Wagner, James M. Wehler, and Robert L. Wright.

In preparing the third edition, I am grateful to Michele Chiuini, Ahmeen Farooq, and Dexter Hulse for their thoughtful reviews of the second edition. While I attempted to incorporate much of their wise counsel, I remain solely responsible for any deficiencies remaining in the text. This edition was the first to be published by John Wiley & Sons, and I therefore want to acknowledge Wiley's editorial and production staff for their invaluable support, and to Nan-Ching Tai for his creative contributions and technical assistance in preparing the electronic component.

Dr. Karen Spence, Gary Crafts, Lohren Deeg, and Dr. Ralph Hammann contributed valuable insights and suggestions for the fourth edition, while Paul Drougas and Lauren Olesky of John Wiley & Sons provided editorial assistance and helped bring the work to a successful conclusion.

For this fifth edition, I want to recognize Todd Green, Amy Odum, and the rest of the Wiley team for their continuing editorial assistance and support, which made this publication not only possible but also an enjoyable endeavor.



To Debra, Emily, and Andrew.

Introduction

Architecture is generally conceived (designed) and realized (built) in response to an existing set of conditions. These conditions may be purely functional in nature, or they may also reflect in varying degrees the social, political, and economic climate. In any case, it is assumed that the existing set of conditions—the problem—is less than satisfactory and that a new set of conditions—a solution—would be desirable. The act of creating architecture, then, is a problem-solving or design process.

The initial phase of any design process is the recognition of a problematic condition and the decision to find a solution to it. Design is above all a willful act, a purposeful endeavor. A designer must first document the existing conditions of a problem, define its context, and collect relevant data to be assimilated and analyzed. This is the critical phase of the design process since the nature of a solution is inexorably related to how a problem is perceived, defined, and articulated. Piet Hein, the noted Danish poet and scientist, puts it this way: "Art is solving problems that cannot be formulated before they have been solved. The shaping of the question is part of the answer."

Designers inevitably and instinctively prefigure solutions to the problems they are confronted with, but the depth and range of their design vocabulary influence both their perception of a question and the shaping of its answer. If one's understanding of a design language is limited, then the range of possible solutions to a problem will also be limited. This book focuses, therefore, on broadening and enriching a vocabulary of design through the study of its essential elements and principles and the exploration of a wide array of solutions to architectural problems developed over the course of human history.

As an art, architecture is more than satisfying the purely functional requirements of a building program. Fundamentally, the physical manifestations of architecture accommodate human activity. However, the arrangement and ordering of forms and spaces also determine how architecture might promote endeavors, elicit responses, and communicate meaning. So while this study focuses on formal and spatial ideas, it is not intended to diminish the importance of the social, political, or economic aspects of architecture. Form and space are presented not as ends in themselves but as means to solve a problem in response to conditions of function, purpose, and context—that is, architecturally.

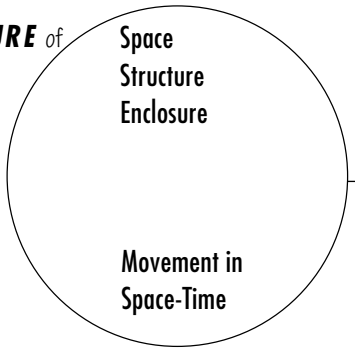
The analogy may be made that one must know and understand the alphabet before words can be formed and a vocabulary developed; one must understand the rules of grammar and syntax before sentences can be constructed; one must understand the principles of composition before essays, novels, and the like can be written. Once these elements are understood, one can write poignantly or with force, call for peace or incite to riot, comment on trivia or speak with insight and meaning. In a similar way, it might be appropriate to be able to recognize the basic elements of form and space and understand how they can be manipulated and organized in the development of a design concept, before addressing the more vital issue of meaning in architecture.

INTRODUCTION

In order to place this study in proper context, the following is an overview of the basic elements, systems, and orders that comprise a work of architecture. All of these constituents can be perceived and experienced. Some may be readily apparent while others are more obscure to our intellect and senses. Some may dominate while others play a secondary role in a building's organization. Some may convey images and meaning while others serve as qualifiers or modifiers of these messages.

In all cases, however, these elements and systems should be interrelated to form an integrated whole having a unifying or coherent structure. Architectural order is created when the organization of parts makes visible their relationships to each other and the structure as a whole. When these relationships are perceived as mutually reinforcing and contributing to the singular nature of the whole, then a conceptual order exists—an order that may well be more enduring than transient perceptual visions.

Architectural Elements



The ***ARCHITECTURE*** of

Space
Structure
Enclosure

- Organizational pattern, relationships, hierarchy, and clarity
- Formal image and spatial definition
- Qualities of shape, color, texture, scale, and proportion
- Qualities of surfaces, edges, and openings

Experienced through

Movement in Space-Time

- Approach and entry
- Path configuration and access to spaces
- Sequence of spaces
- Light, view, touch, sound, and smell

Achieved by means of

Technology

- Structure and enclosure
- Environmental comfort
- Health, safety, and welfare
- Durability, sustainability, and resilience

Accommodating a

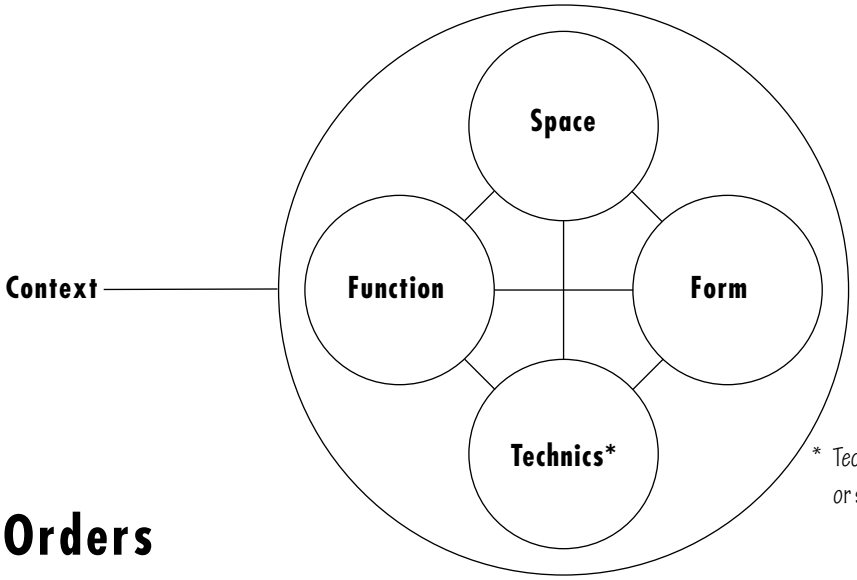
Program

- User requirements, needs, and aspirations
- Sociocultural factors
- Economic factors
- Legal constraints
- Historical tradition and precedents

Compatible with its

Context

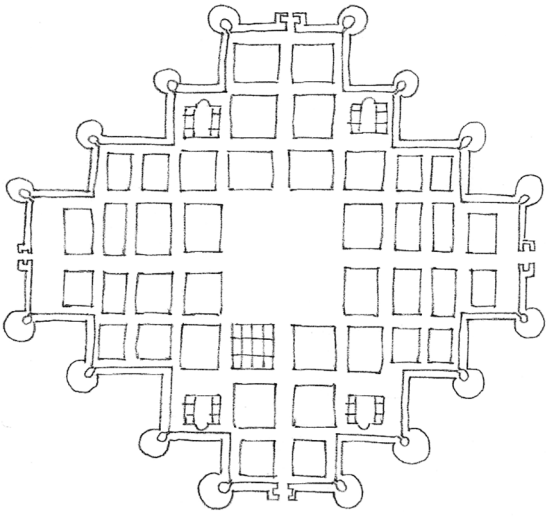
- Site and environment
- Climate: sun, wind, temperature, and precipitation
- Geography: soils, topography, vegetation, and water
- Sensory and cultural characteristics of the place



* Technics refers to the theory, principles, or study of an art or a process.

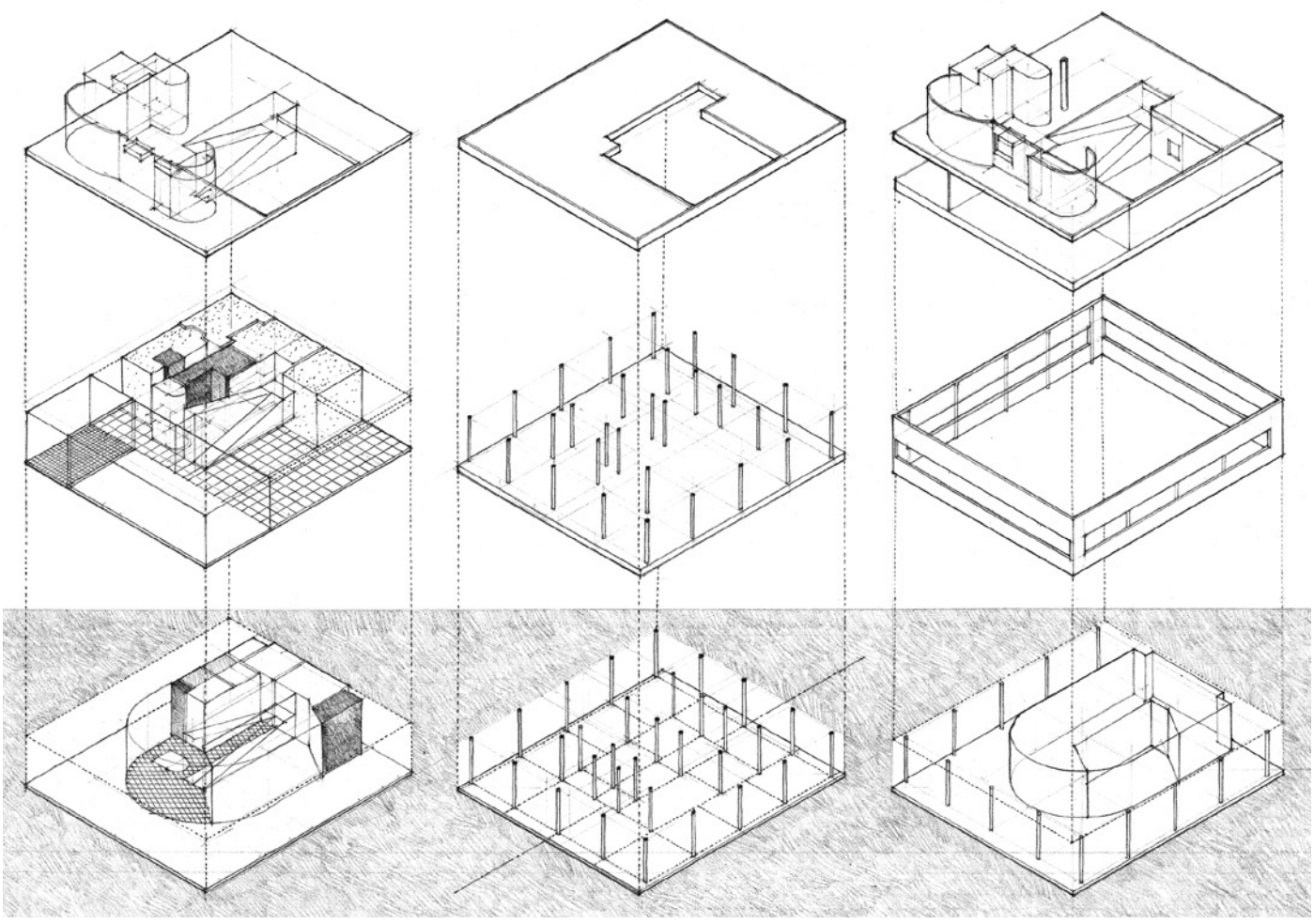
.....& Orders

Physical Orders	**Form and Space** • Solids and voids • Interior and exterior	**Systems and Organizations of** • Space • Structure • Enclosure
Perceptual Orders	Sensory perception and recognition of the physical elements by experiencing them sequentially in time	• Approach and departure • Entry and egress • Movement through the order of spaces • Functioning of and activities within spaces • Qualities of light, color, texture, view, and sound
Conceptual Orders	Comprehension of the ordered or disordered relationships among a building's elements and systems, and responding to the meanings they evoke	• Images • Patterns • Signs • Symbols



INTRODUCTION

This graphic analysis of Villa Savoye (Poissy, east of Paris, 1923–31, Le Corbusier) illustrates the way architecture embodies the harmonious integration of interacting and interrelated parts into a complex and unified whole.



Spatial System

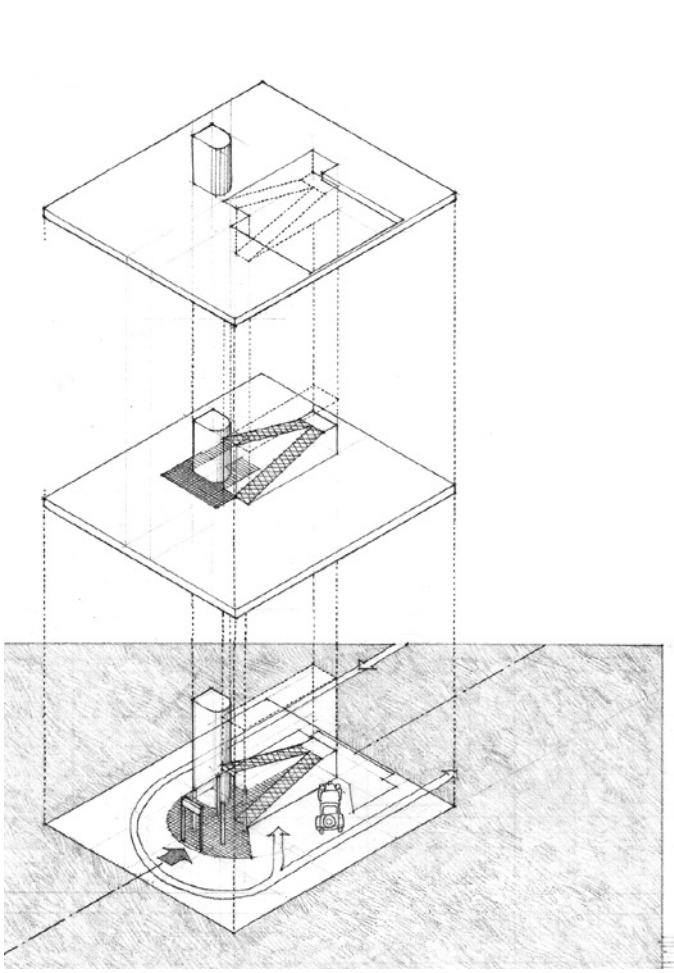
- The three-dimensional integration of program elements and spaces accommodates the multiple functions and relationships of a house.

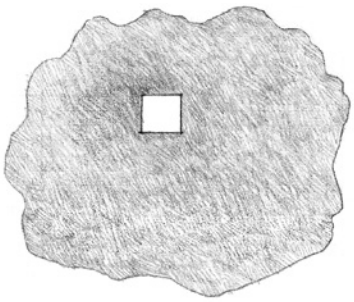
Structural System

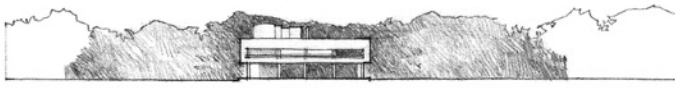
- A grid of columns supports horizontal beams and slabs.
- The cantilever acknowledges the direction of approach along the longitudinal axis.

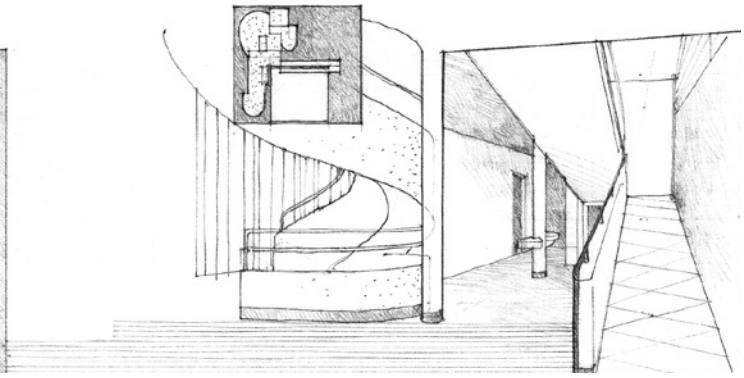
Enclosure System

- Four exterior wall planes define a rectangular volume that contains the program elements and spaces.









Circulation System

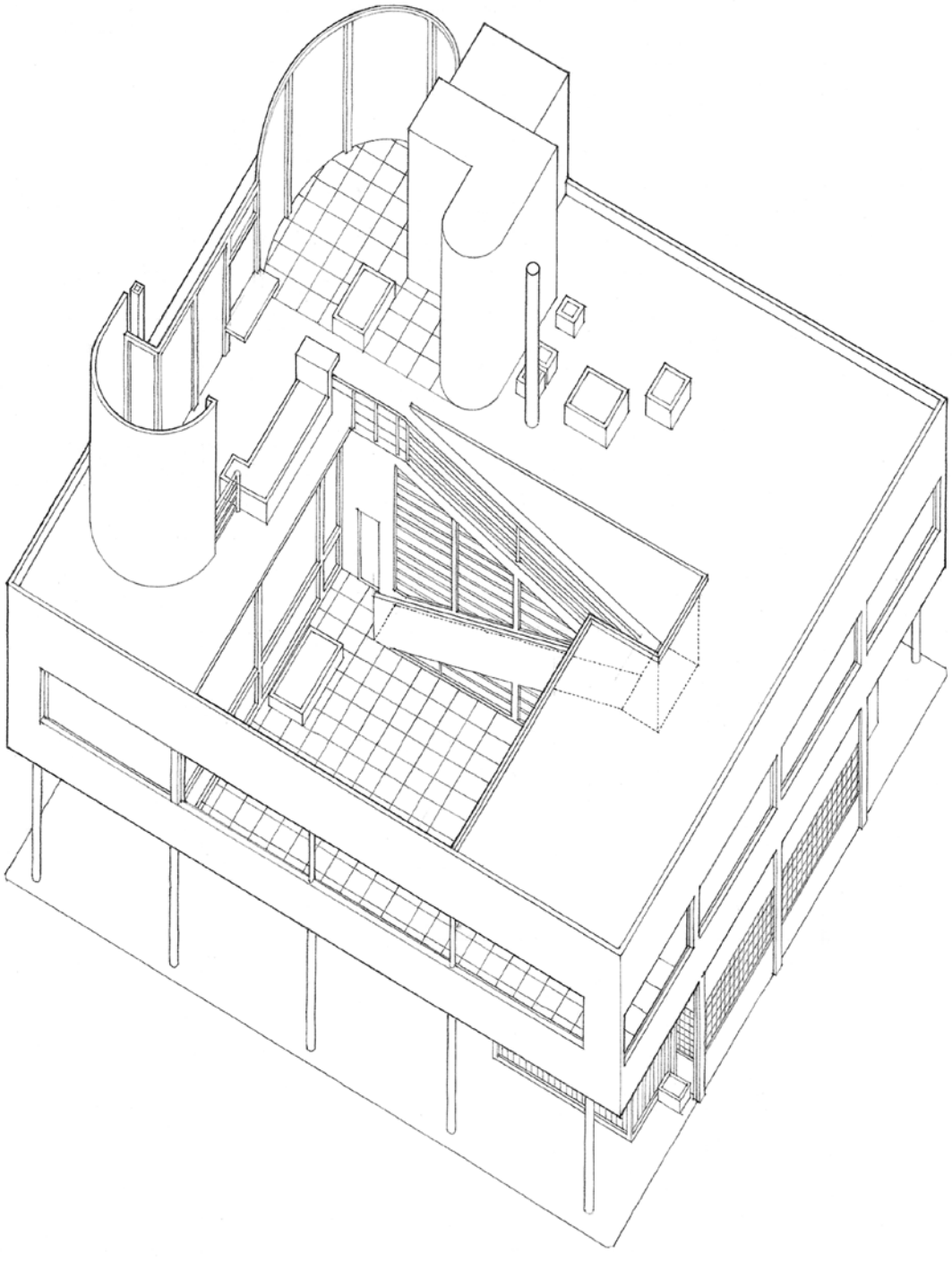
- The stair and ramp penetrate and link the three levels, and heighten the viewer's perception of forms in space and light.
- The curved form of the entrance foyer reflects the movement of the automobile.

Context

- A simple exterior form wraps around a complex interior organization of forms and spaces.
- Elevating the main floor provides a better view and avoids the humidity of the underlying earth.
- A garden terrace distributes sunlight to the spaces gathered around it.

"Its severe, almost square exterior surrounds an intricate interior configuration glimpsed through openings and from protrusions above. . . . Its inside order accommodates the multiple functions of a house, domestic scale, and partial mystery inherent in a sense of privacy. Its outside order expresses the unity of the idea of house at an easy scale appropriate to the green field it dominated and possibly to the city it will one day be part of."

Robert Venturi, *Complexity and Contradiction in Architecture*, 1966



1

Primary Elements

"All pictorial form begins with the point that sets itself in motion . . .
The point moves . . . and the line comes into being—the first dimension.
If the line shifts to form a plane, we obtain a two-dimensional element.
In the movement from plane to spaces, the clash of planes gives rise to
body (three-dimensional) . . . A summary of the kinetic energies
which move the point into a line, the line into a plane,
and the plane into a spatial dimension."

Paul Klee
The Thinking Eye: The Notebooks of Paul Klee
(English translation)
1961

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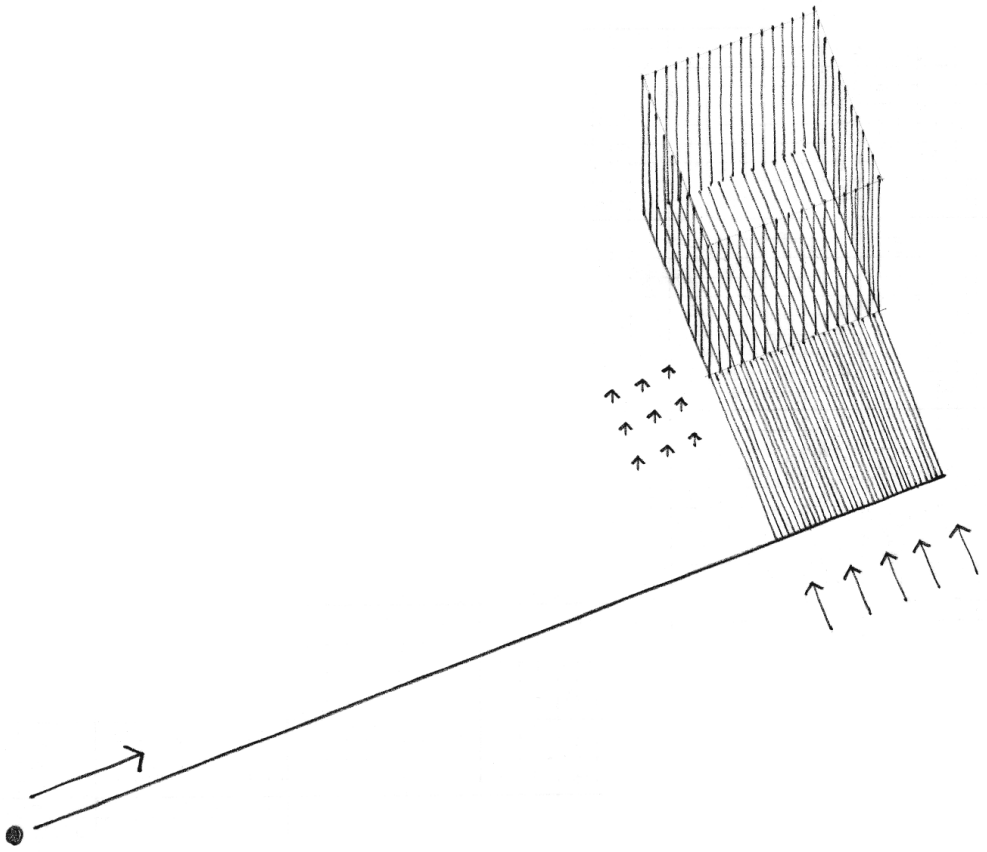
PRIMARY ELEMENTS

This opening chapter presents the primary elements of form in the order of their growth from the point to a one-dimensional line, from the line to a two-dimensional plane, and from the plane to a three-dimensional volume. Each element is first considered as a conceptual element, then as a visual element in the vocabulary of architectural design.

As conceptual elements, the point, line, plane, and volume are not visible except to the mind's eye. While they do not actually exist, we nevertheless feel their presence. We can sense a point at the meeting of two lines, a line marking the contour of a plane, a plane enclosing a volume, and the volume of an object that occupies space.

When made visible to the eye on paper or in three-dimensional space, these elements become form with characteristics of substance, shape, size, color, and texture. As we experience these forms in our environment, we should be able to perceive in their structure the existence of the primary elements of point, line, plane, and volume.



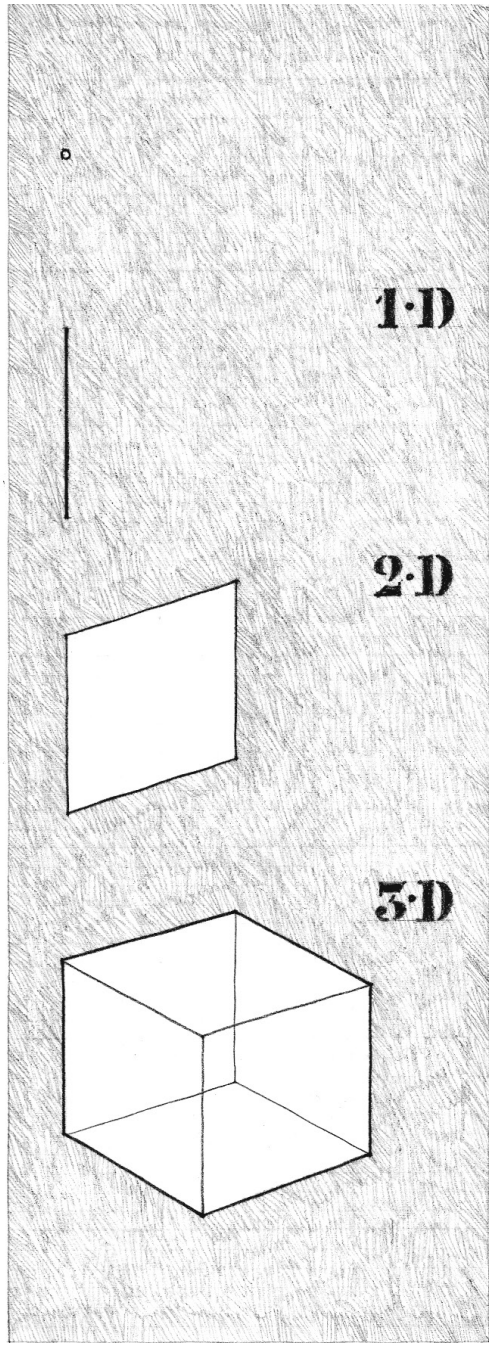
As the prime generator of form, the

Point indicates a position in space.

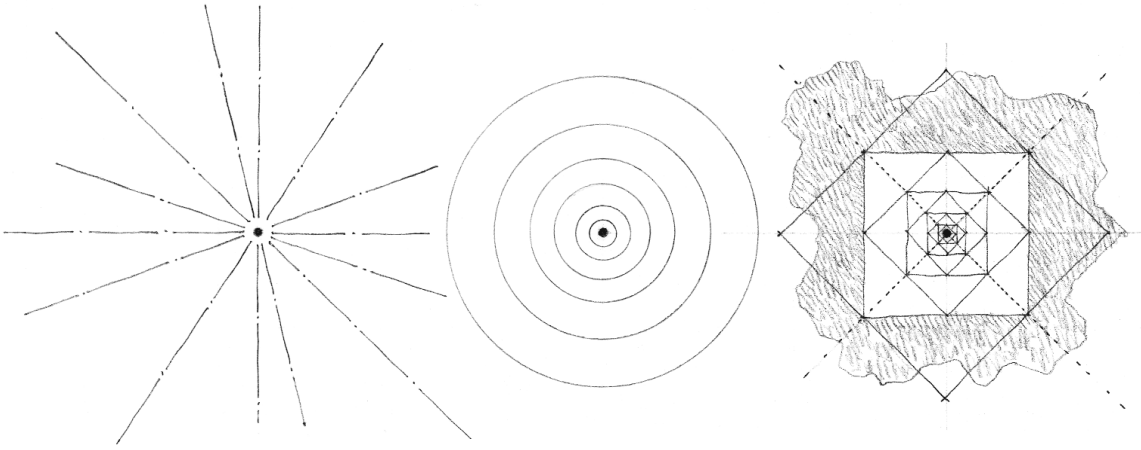
Line A point extended becomes a with properties of:
- Length
- Direction
- Position

Plane A line extended becomes a with properties of:
- Length and width
- Shape
- Surface
- Orientation
- Position

Volume A plane extended becomes a with properties of:
- Length, width, and depth
- Form and space
- Surface
- Orientation
- Position



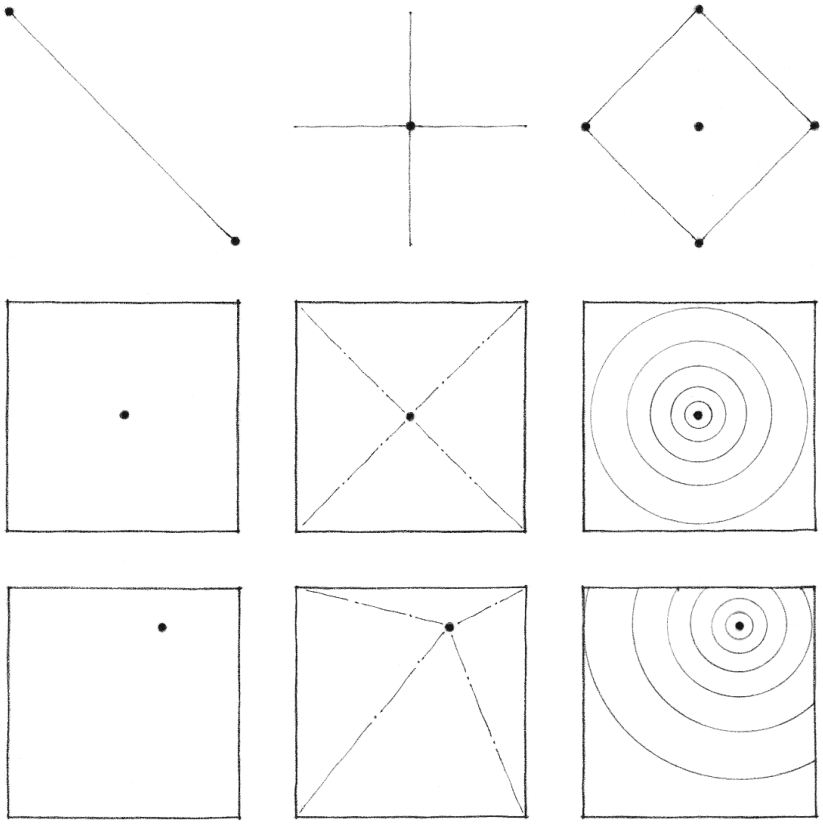
POINT



A point marks a position in space. Conceptually, it has no length, width, or depth, and is therefore static, centralized, and directionless.

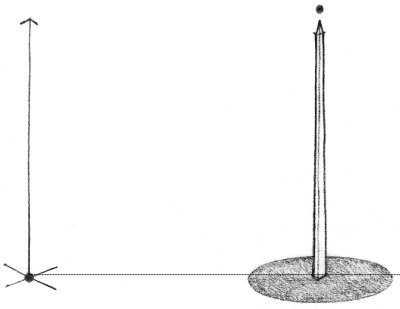
As the prime element in the vocabulary of form, a point can serve to mark:

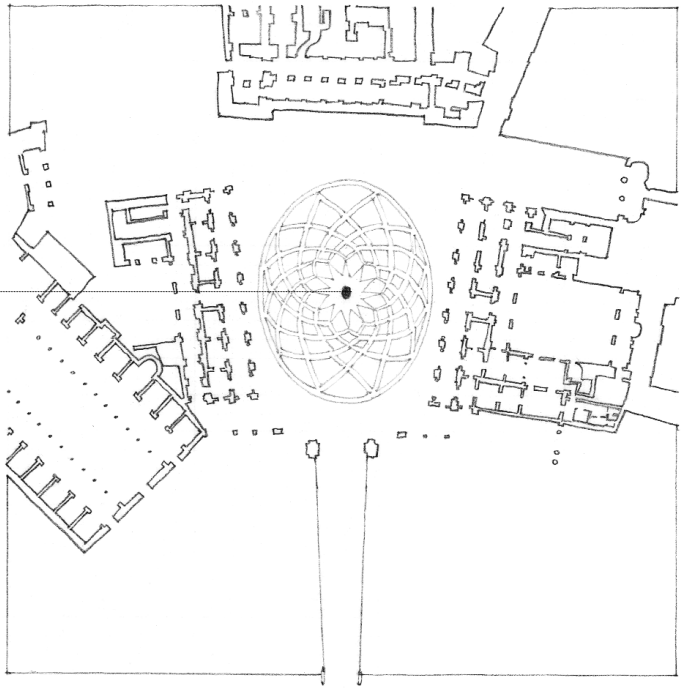
- The two ends of a line
- The intersection of two lines
- The meeting of lines at the corner of a plane or volume
- The center of a field



Although a point theoretically has neither shape nor form, it begins to make its presence felt when placed within a visual field. At the center of its environment, a point is stable and at rest, organizing surrounding elements about itself and dominating its field.

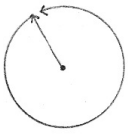
When the point is moved off-center, however, its field becomes more aggressive and begins to compete for visual supremacy. Visual tension is created between the point and its field.



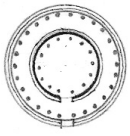


Piazza del Campidoglio, Rome, c. 1544, Michelangelo Buonarroti.
The equestrian statue of Marcus Aurelius marks the center of this urban space.

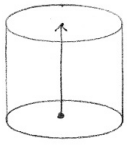
A point has no dimension. To visibly mark a position in space or on the ground plane, a point must be projected vertically into a linear form, as a column, obelisk, or tower. Any such columnar element is seen in plan as a point and therefore retains the visual characteristics of a point. Other point-generated forms that share these same visual attributes are the:



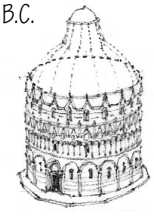
Circle



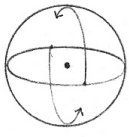
Tholos of Polycleitos, Epidauros, Greece, c. 350 B.C.



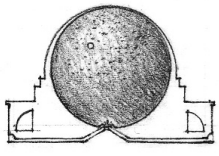
Cylinder



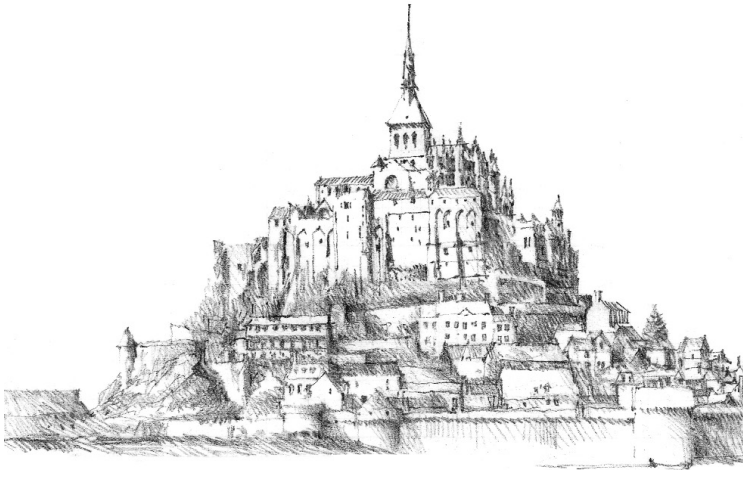
Baptistery at Pisa, Italy, 1153–1265, Diotisalvi



Sphere



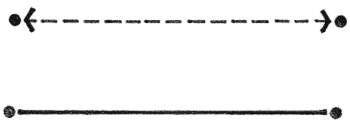
Cenotaph for Sir Isaac Newton, Project, 1784, Étienne-Louis Boulée

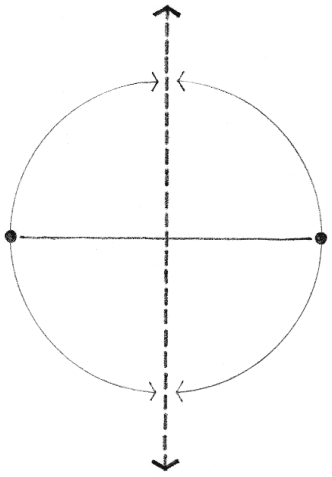


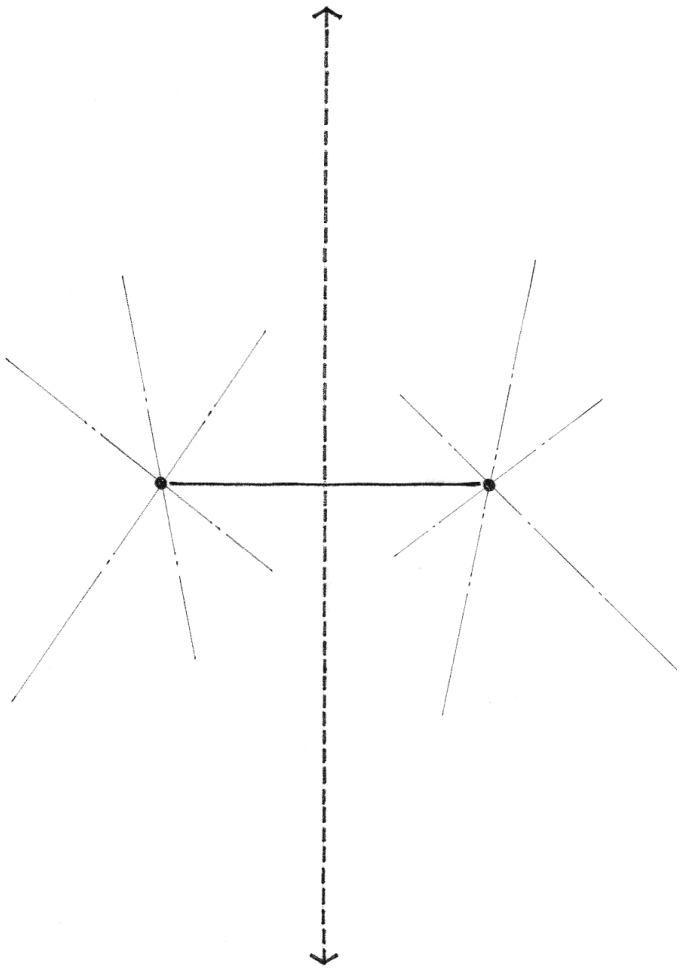
Mont St. Michel, France, 13th century and later.
The pyramidal composition culminates in a spire that serves to establish this fortified monastery as a specific place in the landscape.

TWO POINTS

Two points describe a line that connects them. Although the points give this line finite length, the line can also be considered a segment of an infinitely longer path.



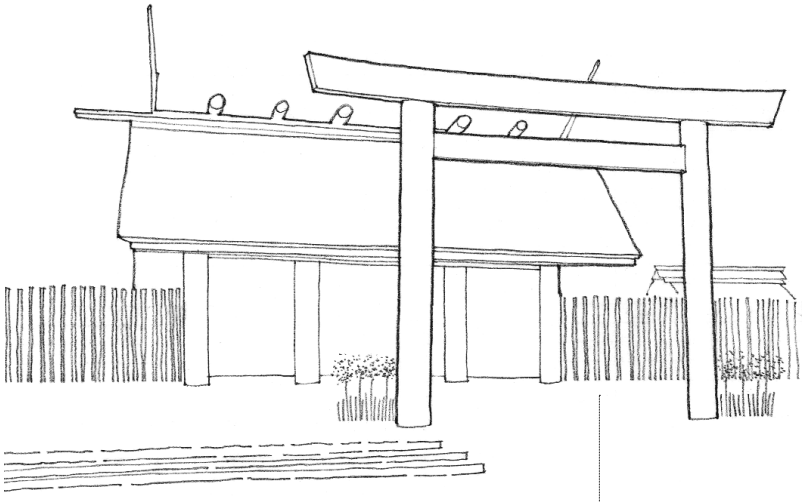




Two points further suggest an axis perpendicular to the line they describe and about which they are symmetrical. Because this axis may be infinite in length, it can be at times more dominant than the described line.

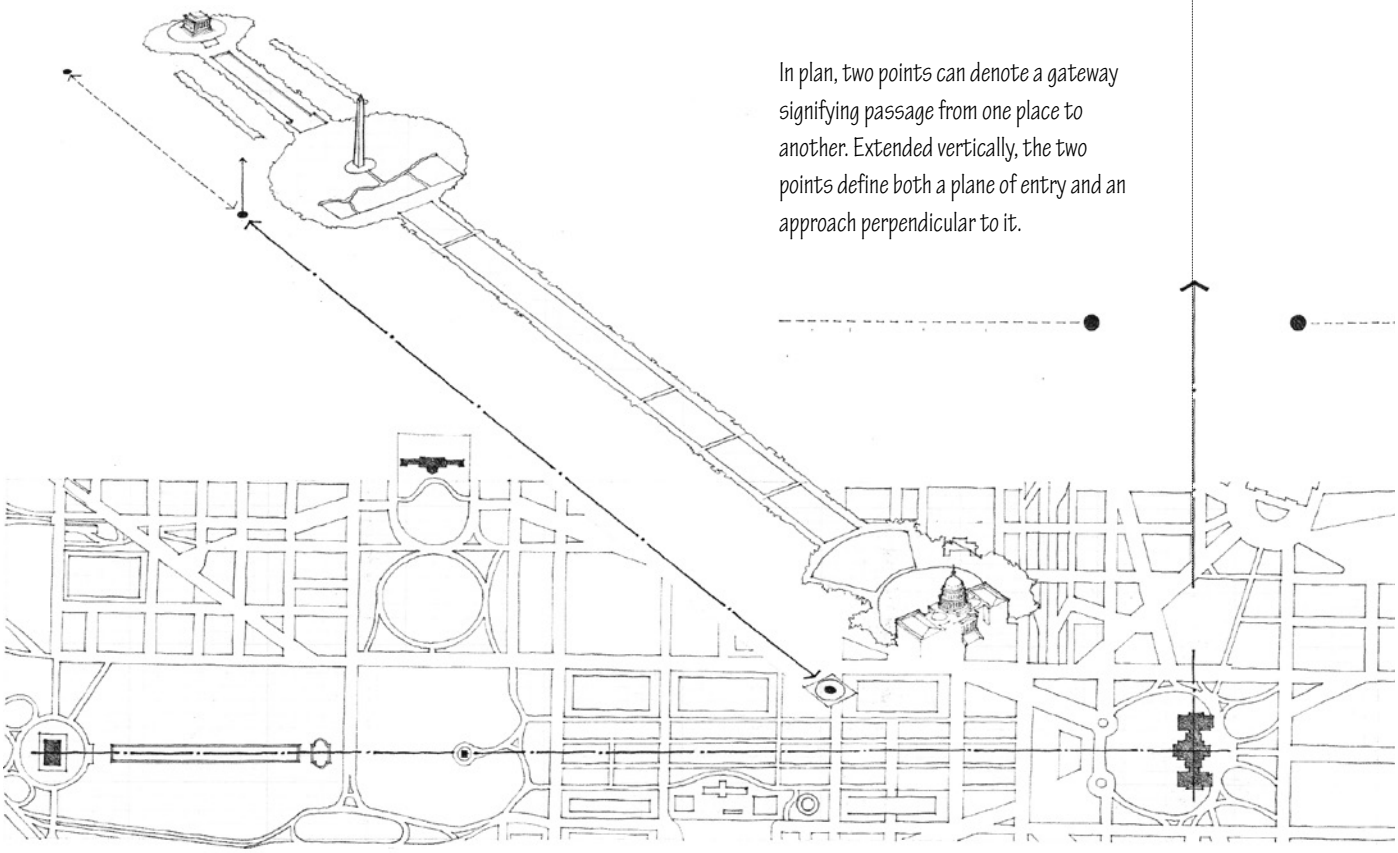
In both cases, however, the described line and the perpendicular axis are optically more dominant than the infinite number of lines that may pass through each of the individual points.

Two points established in space by columnar elements or centralized forms can define an axis, an ordering device used throughout history to organize building forms and spaces.



Torii, Ise Shrine, Mie Prefecture, Japan, A.D. 690

In plan, two points can denote a gateway signifying passage from one place to another. Extended vertically, the two points define both a plane of entry and an approach perpendicular to it.

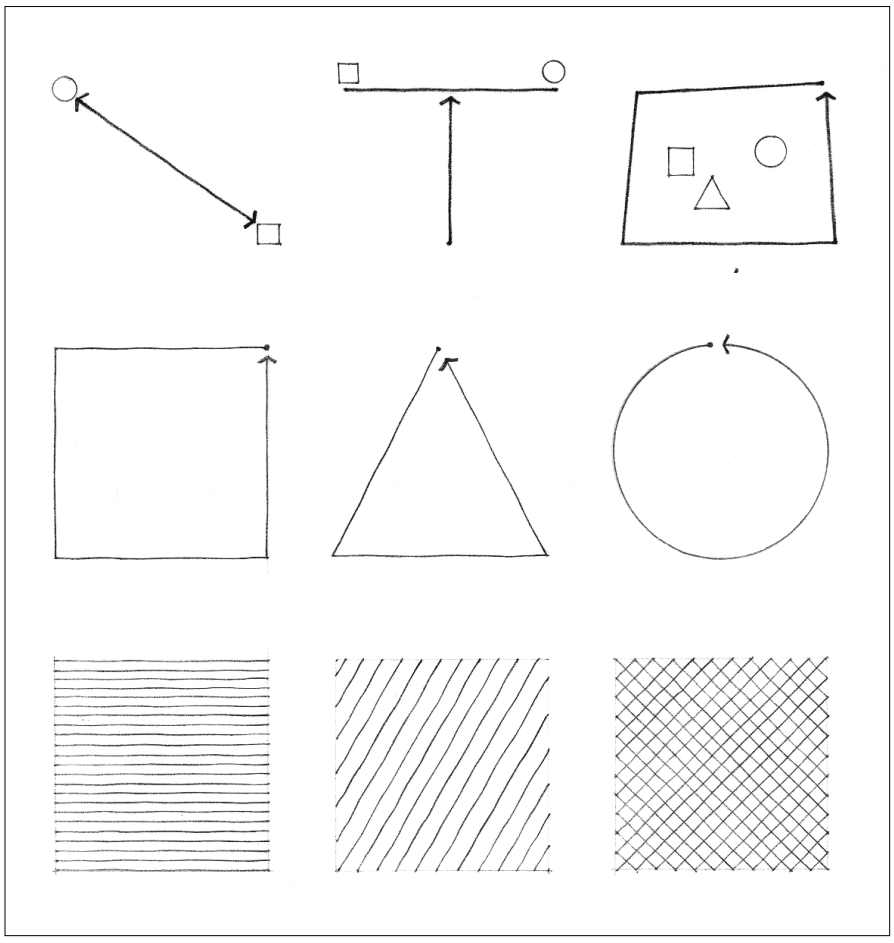


The Mall, Washington, D.C., lies along the axis established by the Lincoln Memorial, the Washington Monument, and the United States Capitol building.

LINE

A point extended becomes a line. Conceptually, a line has length, but no width or depth. Whereas a point is by nature static, a line, in describing the path of a point in motion, is capable of visually expressing direction, movement, and growth.

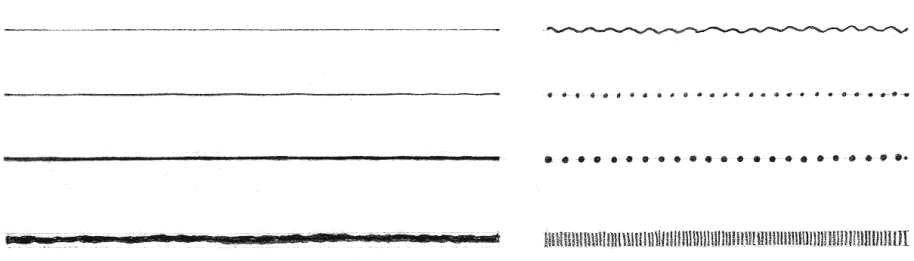
A line is a critical element in the formation of any visual construction.



A line can serve to:

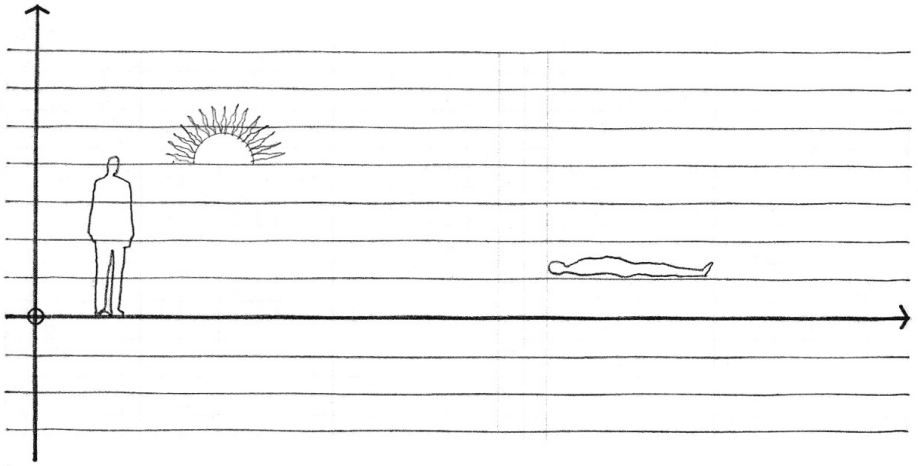
- Join, link, support, surround, or intersect other visual elements
- Describe the edges of and give shape to planes
- Articulate the surfaces of planes

Although a line theoretically has only one dimension, it must have some degree of thickness to become visible. It is seen as a line simply because its length dominates its width. The character of a line, whether taut or limp, bold or tentative, graceful or ragged, is determined by our perception of its length–width ratio, its contour, and its degree of continuity.

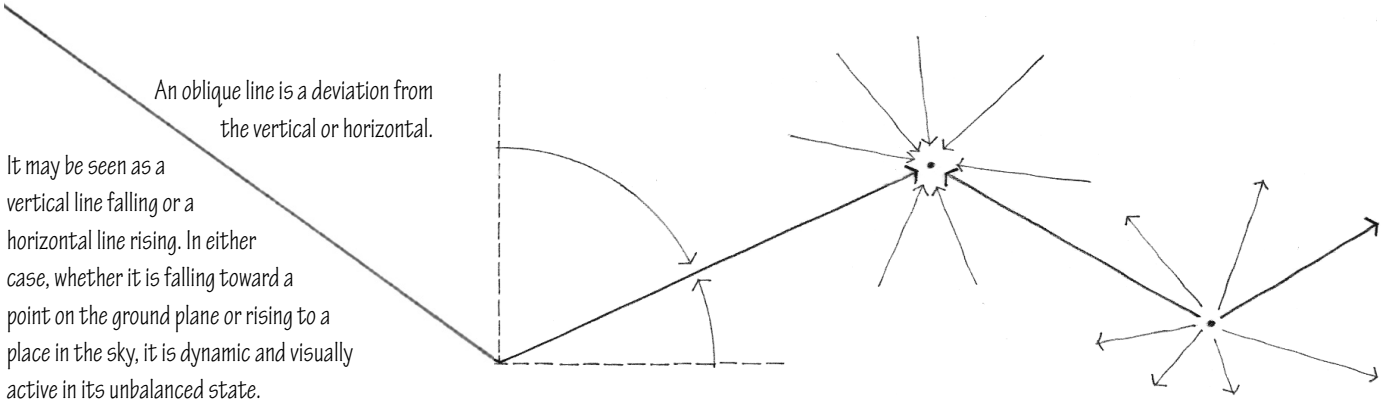


Even the simple repetition of like or similar elements, if continuous enough, can be regarded as a line. This type of line has significant textural qualities.

The orientation of a line affects its role in a visual construction. While a vertical line can express a state of equilibrium with the force of gravity, symbolize the human condition, or mark a position in space, a horizontal line can represent stability, the ground plane, the horizon, or a body at rest.

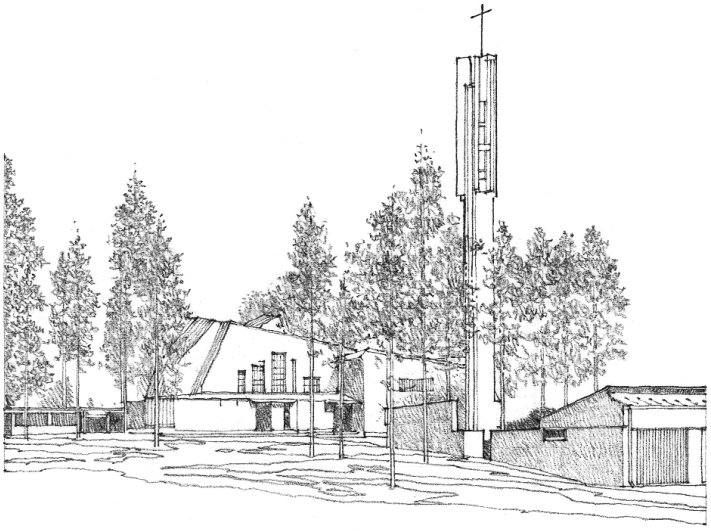


An oblique line is a deviation from the vertical or horizontal. It may be seen as a vertical line falling or a horizontal line rising. In either case, whether it is falling toward a point on the ground plane or rising to a place in the sky, it is dynamic and visually active in its unbalanced state.

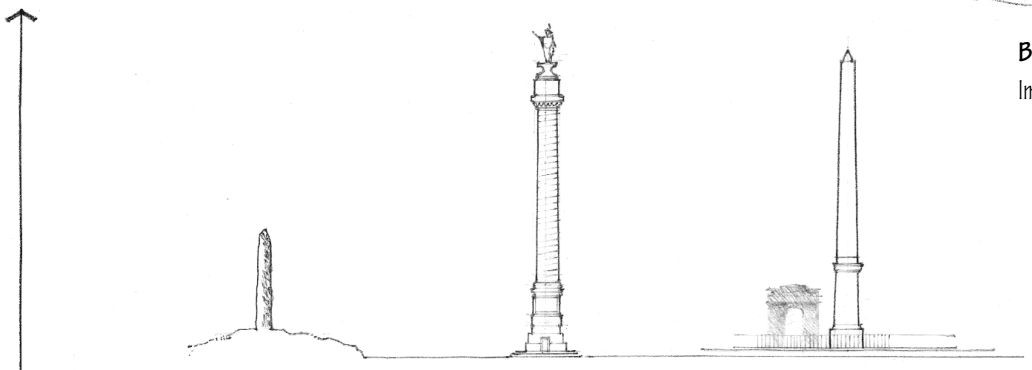


LINEAR ELEMENTS

Vertical linear elements, such as columns, obelisks, and towers, have been used throughout history to commemorate significant events and establish particular points in space.



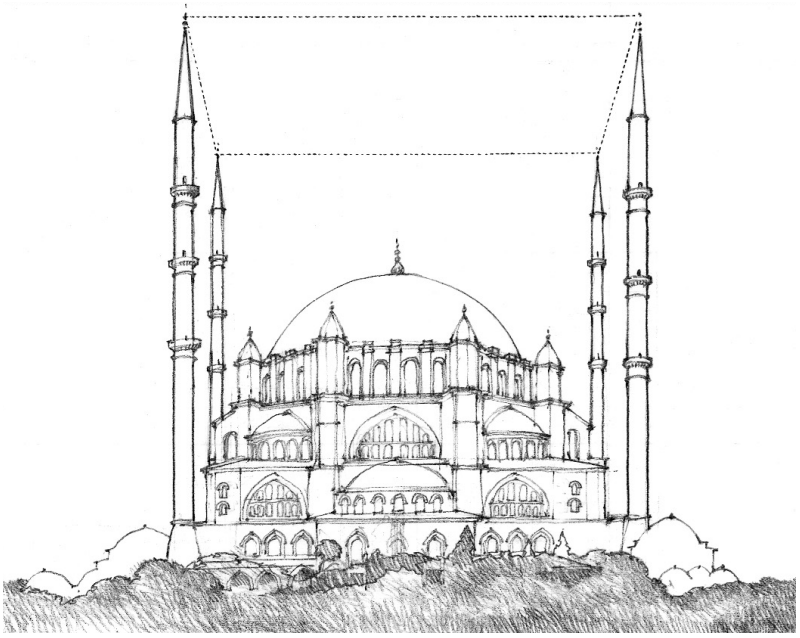
Bell Tower, Church at Vuoksenniska, Imatra, Finland, 1956, Alvar Aalto



Menhir, a prehistoric monument consisting of an upright megalith, usually standing alone but sometimes aligned with others.

Column of Marcus Aurelius, Piazza Colonna, Rome, A.D. 174. This cylindrical shaft commemorates the emperor's victory over Germanic tribes north of the Danube.

Obelisk of Luxor, Place de la Concorde, Paris. The obelisk, which marked the entrance to the Amon Temple at Luxor, was given by the viceroy of Egypt, Mohamed Ali, to Louis Phillipe and was installed in 1836.

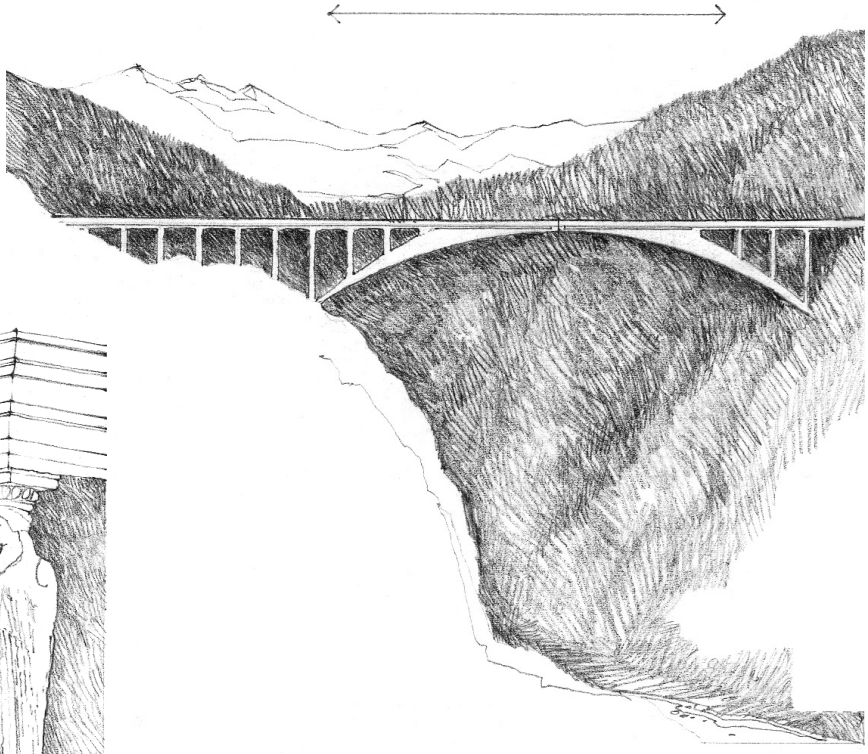


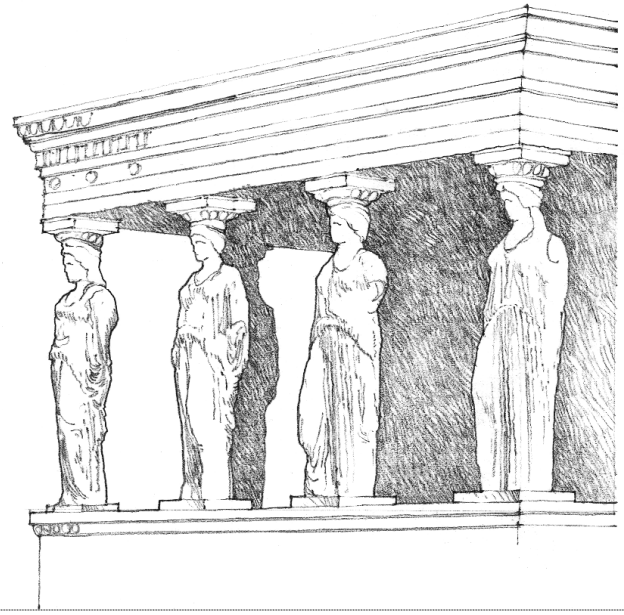
Vertical linear elements can also define a transparent volume of space. In the example illustrated to the left, four minaret towers outline a spatial field from which the dome of the Selim Mosque rises in splendor.

Selim Mosque, Edirne, Turkey, 1569–1575, Mimar Sinan

Linear members that possess the necessary material strength can perform structural functions. In these three examples, linear elements:

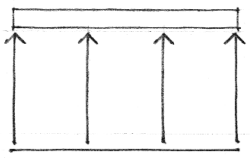
- Express movement across space
- Provide support for an overhead plane
- Form a three-dimensional structural frame for architectural space

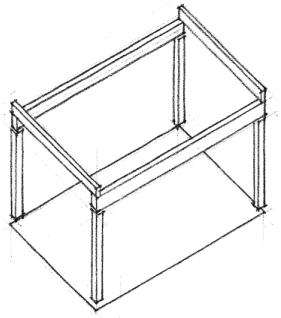


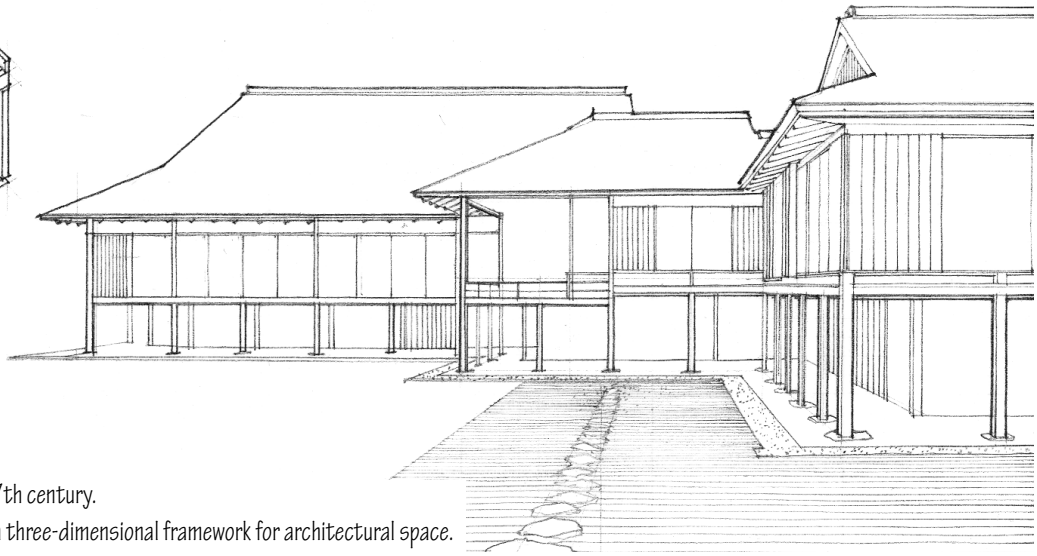


Caryatid Porch, The Erechtheion, Athens, 421–405 B.C., Mnesicles.
The sculptured female figures stand as columnar supports for the entablature.

Salginatobel Bridge, Switzerland, 1929–1930, Robert Maillart.
Beams and girders have the bending strength to span the space between their supports and carry transverse loads.

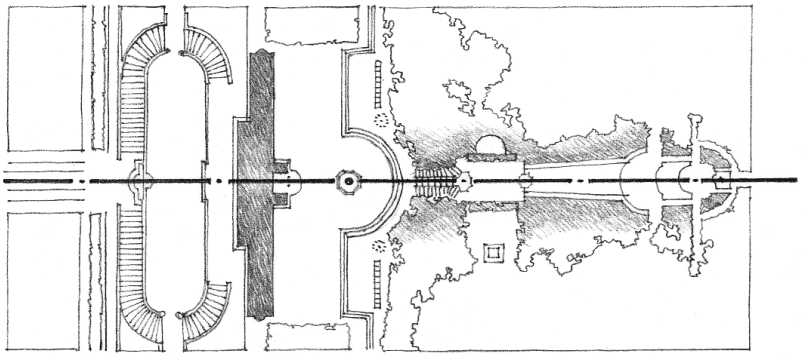






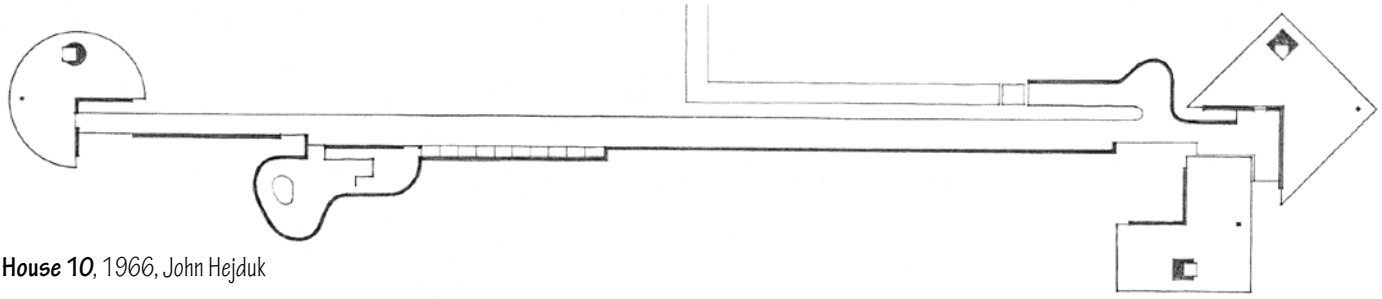
Katsura Imperial Villa, Kyoto, Japan, 17th century.
Linear columns and beams together form a three-dimensional framework for architectural space.

LINEAR ELEMENTS



A line can be an imagined element rather than a visible one in architecture. An example is the axis, a regulating line established by two distant points in space and about which elements are symmetrically arranged.

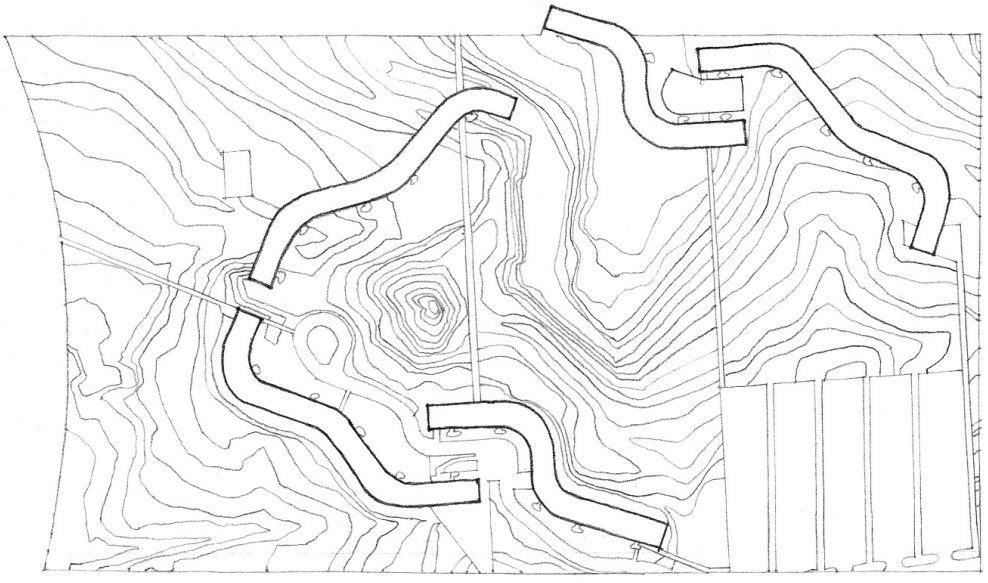
Villa Aldobrandini, Italy, 1598–1603, Giacomo Della Porta



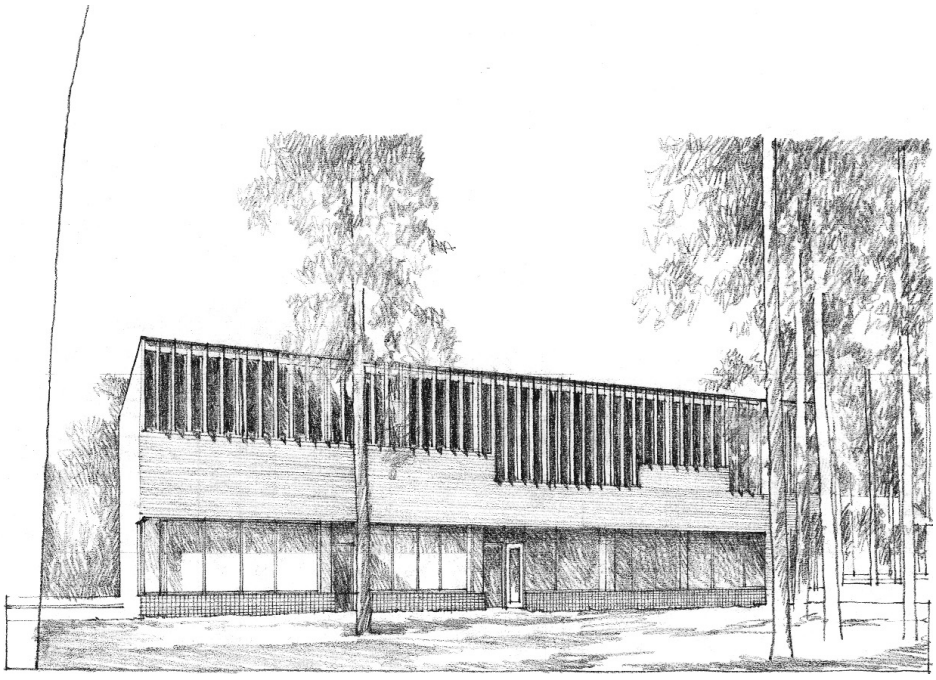
House 10, 1966, John Hejduk

Although architectural space exists in three dimensions, it can be linear in form to accommodate the path of movement through a building and link its spaces to one another.

Buildings also can be linear in form, particularly when they consist of repetitive spaces organized along a circulation path. As illustrated here, linear building forms have the ability to enclose exterior spaces as well as adapt to the environmental conditions of a site.

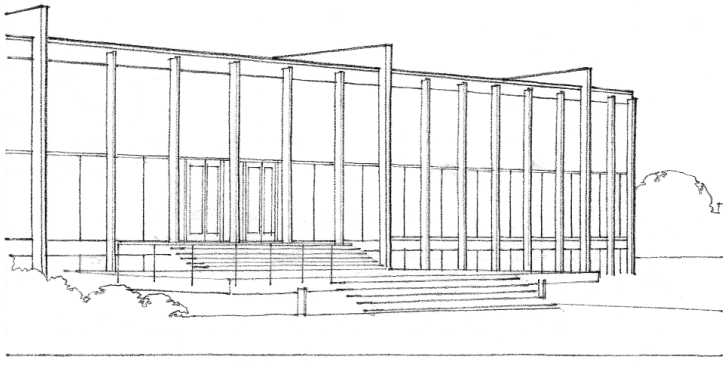


Cornell University Undergraduate Housing (Project), Ithaca, New York, 1974, Richard Meier

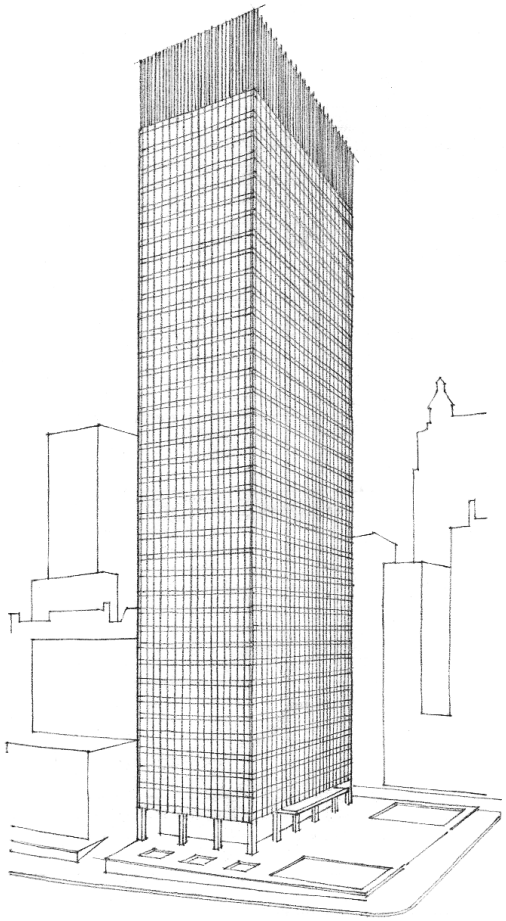


Town Hall, Säynätsalo, Finland, 1950–1952, Alvar Aalto

At a smaller scale, lines articulate the edges and surfaces of planes and volumes. These lines can be expressed by joints within or between building materials, by frames around window or door openings, or by a structural grid of columns and beams. How these linear elements affect the texture of a surface will depend on their visual weight, spacing, and direction.

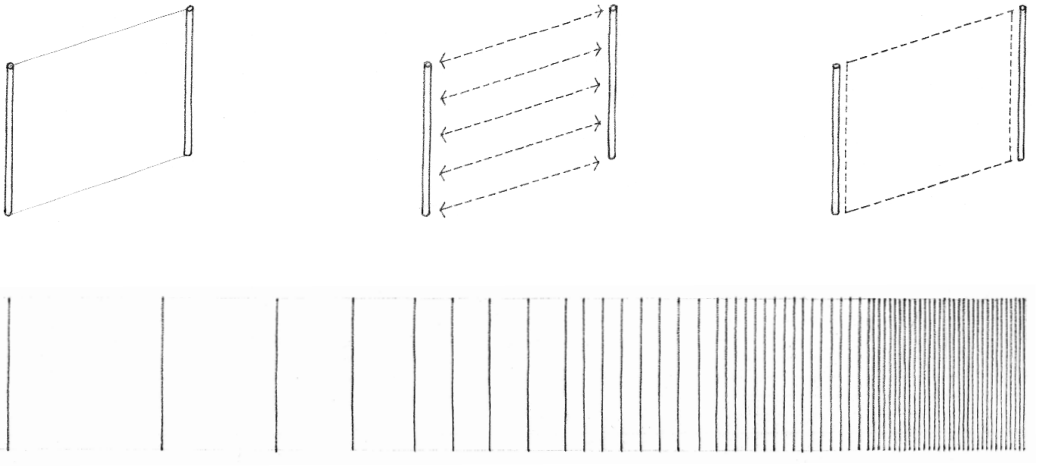


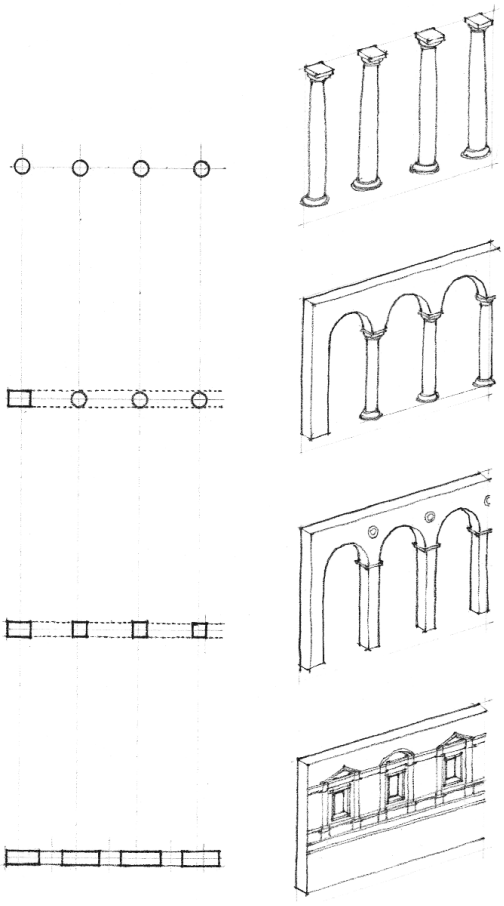
Crown Hall, School of Architecture and Urban Design, Illinois Institute of Technology, Chicago, 1956, Mies van der Rohe



Seagram Building, New York City, 1956–1958, Mies van de Rohe and Philip Johnson

FROM LINE TO PLANE



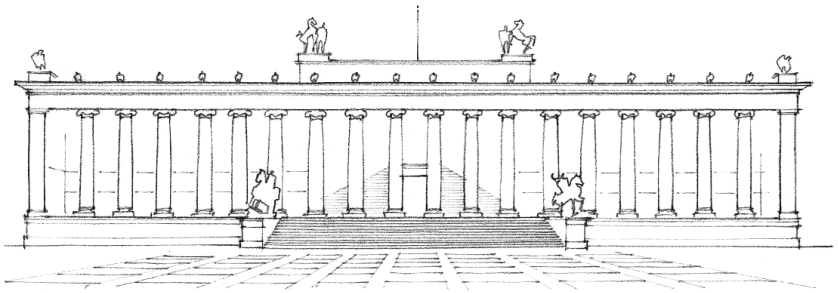


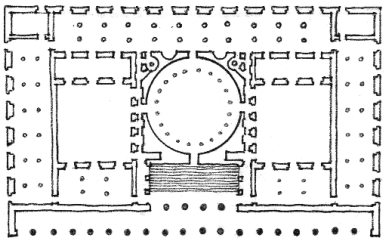
Two parallel lines have the ability to visually describe a plane. A transparent spatial membrane can be stretched between them to acknowledge their visual relationship. The closer these lines are to each other, the stronger will be the sense of plane they convey.

A series of parallel lines, through their repetitiveness, reinforces our perception of the plane they describe. As these lines extend themselves along the plane they describe, the implied plane becomes real and the original voids between the lines revert to being mere interruptions of the planar surface.

The diagrams illustrate the transformation of a row of round columns, initially supporting a portion of a wall, then evolving into square piers which are an integral part of the wall plane, and finally becoming pilasters—remnants of the original columns occurring as a relief along the surface of the wall.

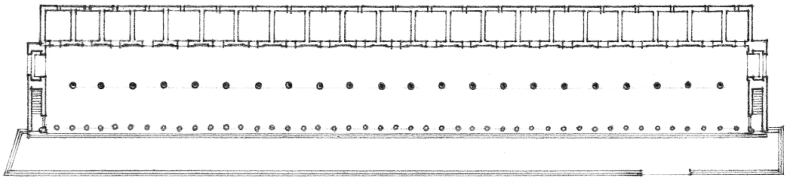
"The column is a certain strengthened part of a wall, carried up perpendicular from the foundation to the top . . . A row of columns is indeed nothing but a wall, open and discontinued in several places." *Leon Battista Alberti*

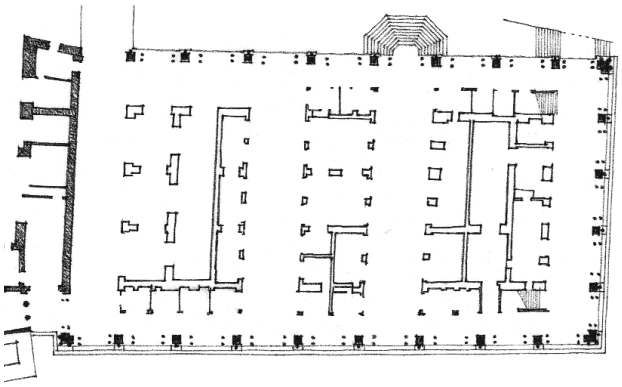




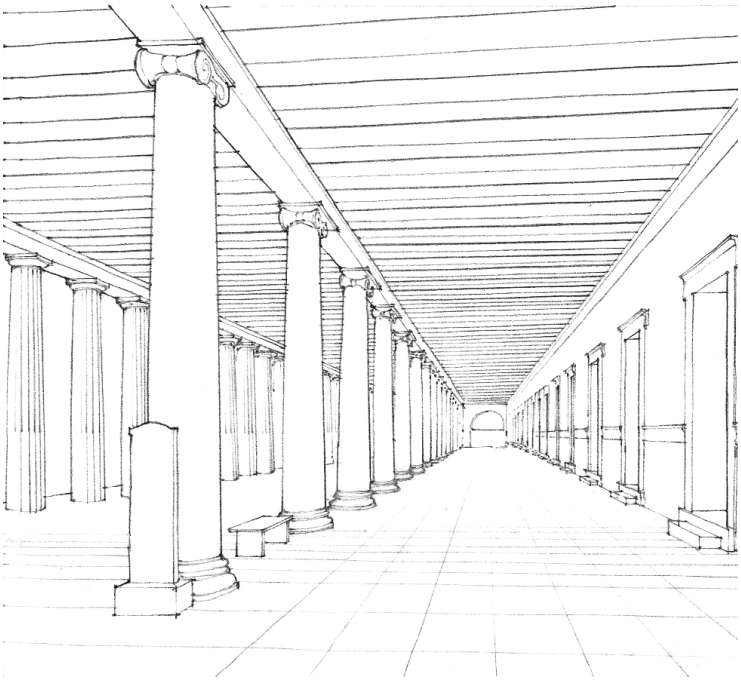
Altes Museum, Berlin, 1823–1830, Karl Friedrich Schinkel

A row of columns supporting an entablature—a colonnade—is often used to define the public face or facade of a building, especially one that fronts on a major civic space. A colonnaded facade can be penetrated easily for entry, offers a degree of shelter from the elements, and forms a semi-transparent screen that unifies individual building forms behind it.



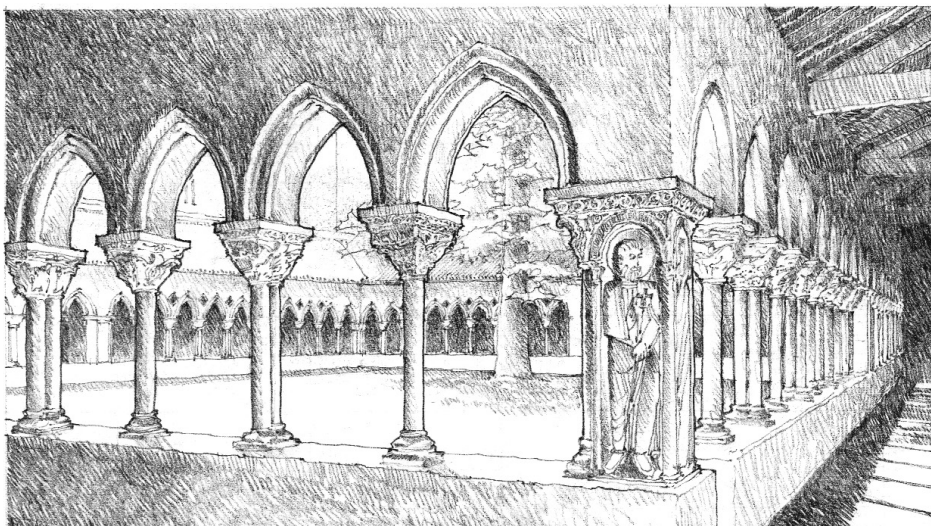


The Basilica, Vicenza, Italy.
Andrea Palladio designed this two-story loggia in 1545 to wrap around an existing medieval structure. This addition not only buttressed the existing structure but also acted as a screen that disguised the irregularity of the original core and presented a uniform but elegant face to the Piazza del Signori.



Stoa of Attalus fronting the Agora in Athens

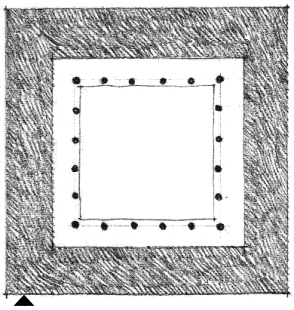
LINEAR ELEMENTS DEFINING PLANES

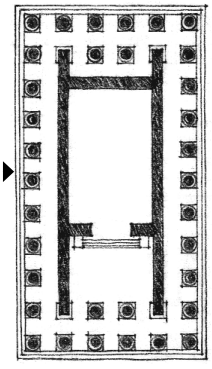


Cloister of **Moissac Abbey**, France, c. 1100

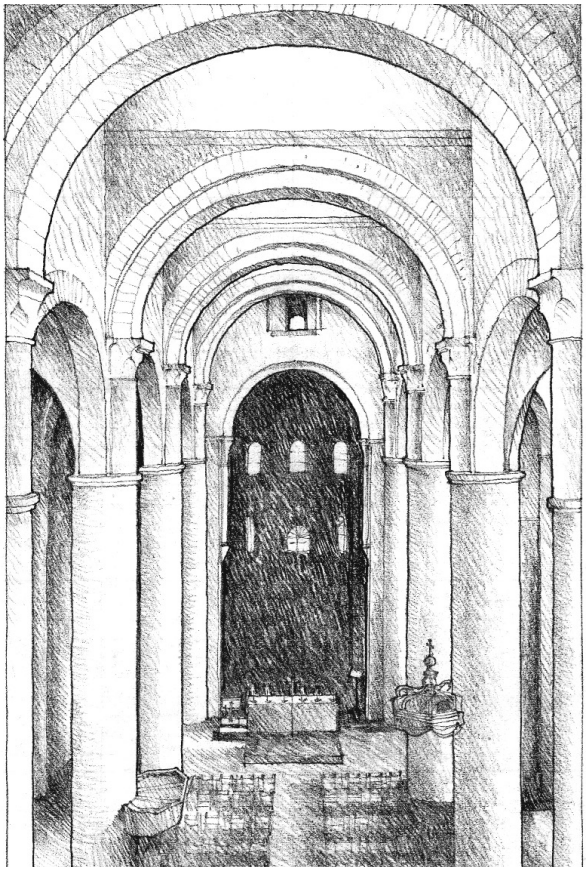
In addition to the structural role columns play in supporting an overhead floor or roof plane, they can articulate the penetrable boundaries of spatial zones that mesh easily with adjacent spaces.

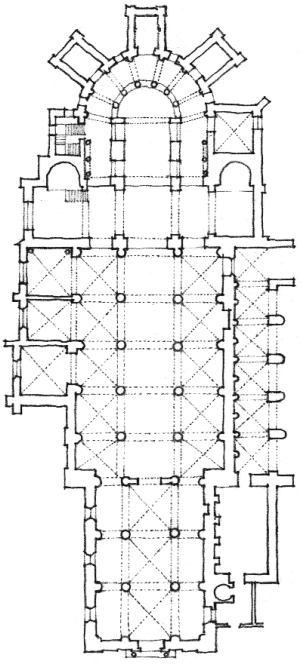
These two examples illustrate how columns can define the edges of an exterior space defined within the mass of a building as well as articulate the edges of a building mass in space.



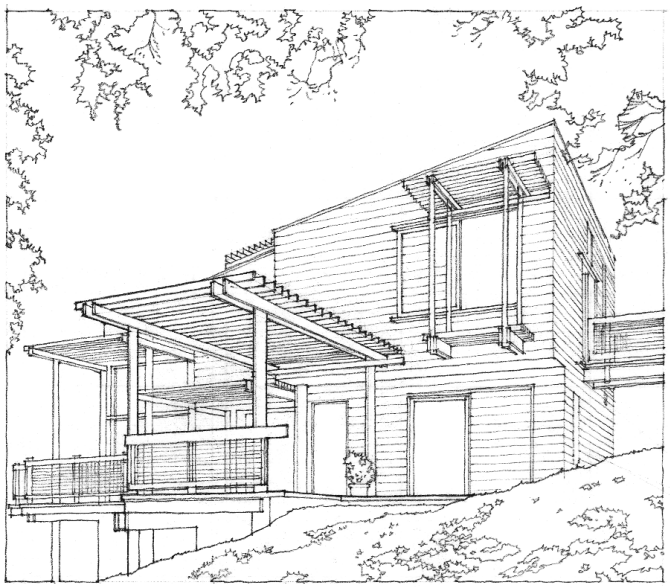


Temple of Athena Polias, Priene, c. 334 B.C., Pythius

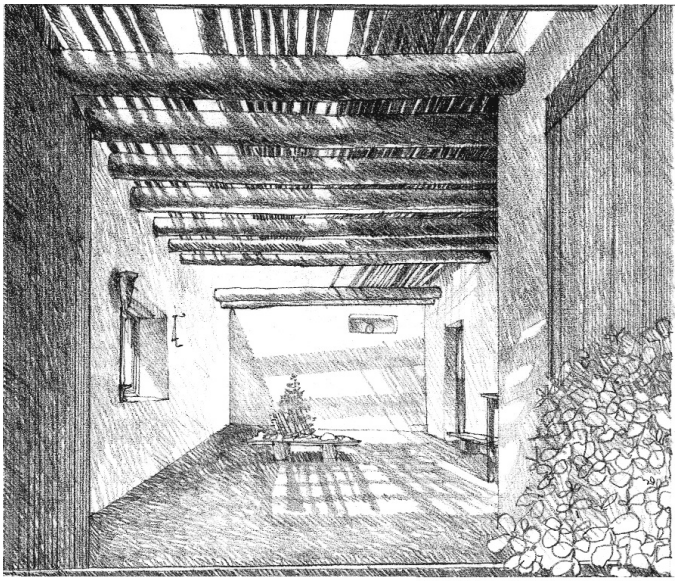




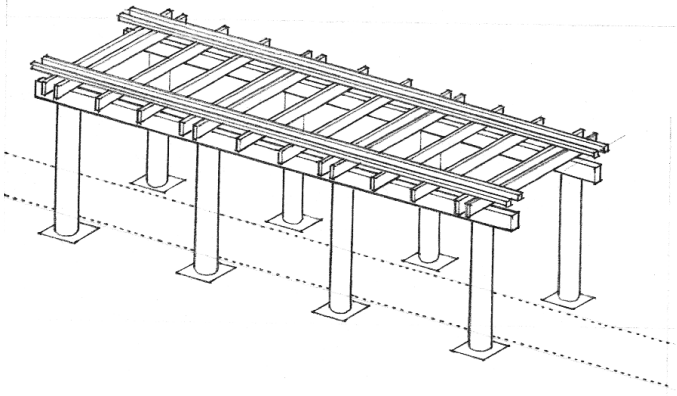
St. Philibert, Tournus, France, 950–1120. This view of the nave shows how rows of columns can provide a rhythmic measure of space.



Cary House, Mill Valley, California, 1963, Joseph Esherick

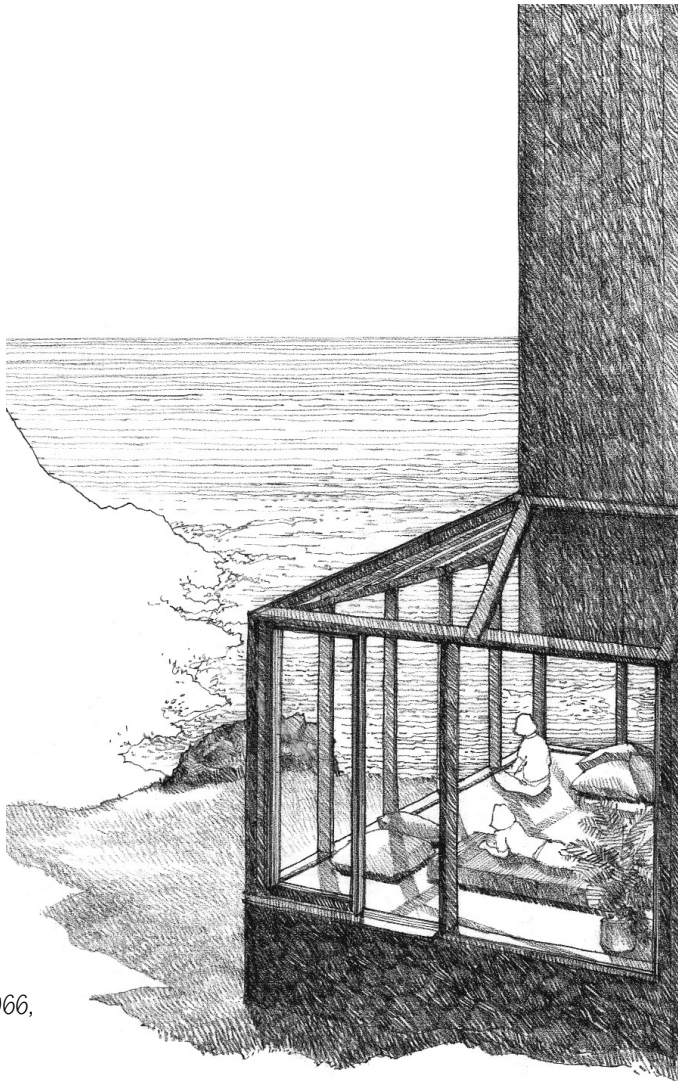


Trellised Courtyard, **Georgia O'Keefe Residence**, Abiquiu, northwest of Sante Fe, New Mexico



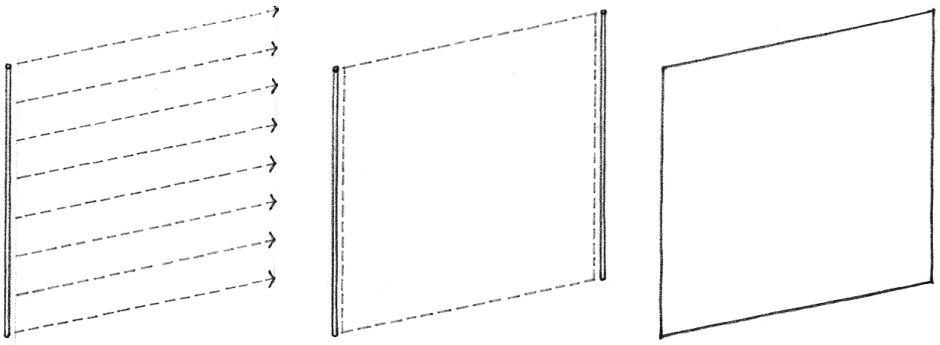
The linear members of trellises and pergolas can provide a moderate degree of definition and enclosure for outdoor spaces while allowing filtered sunlight and breezes to penetrate.

Vertical and horizontal linear elements together can define a volume of space such as the solarium illustrated to the right. Note that the form of the volume is determined solely by the configuration of the linear elements.

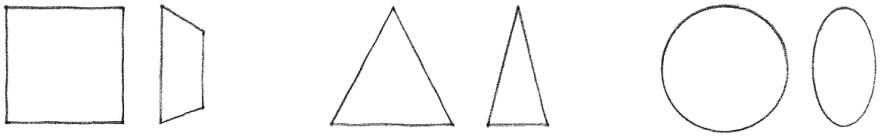


Solarium of **Condominium Unit 1, Sea Ranch**, California, 1966, Moore, Lyndon, Turnbull, Whitaker (MLTW)

PLANE

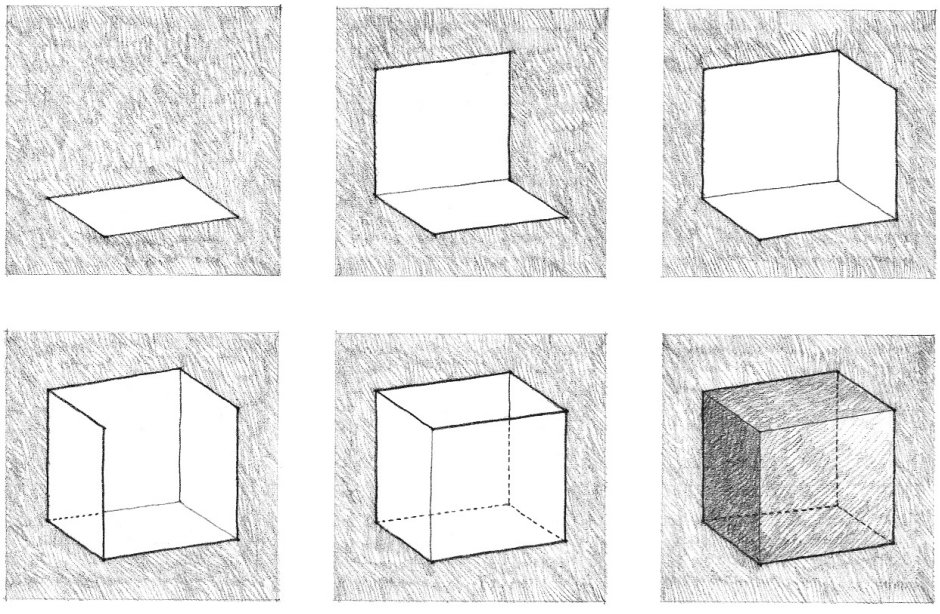


A line extended in a direction other than its intrinsic direction becomes a plane. Conceptually, a plane has length and width, but no depth.



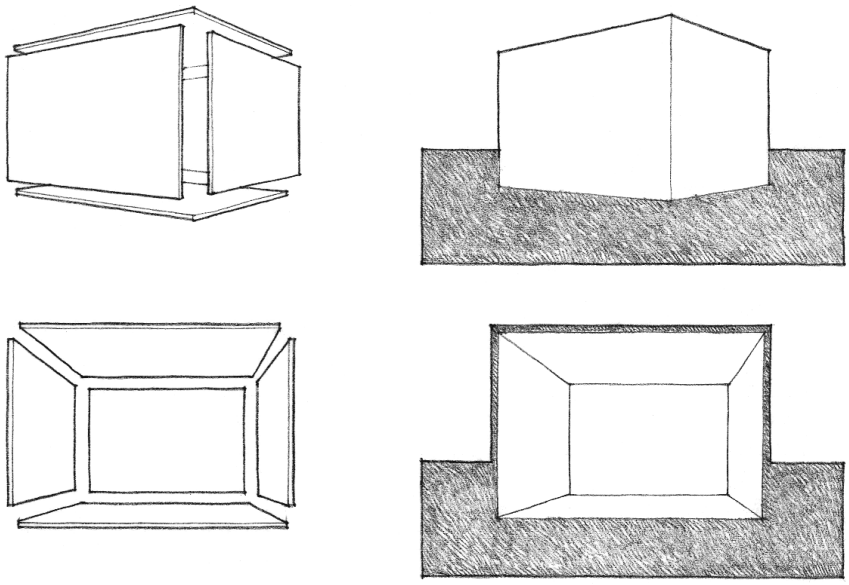
Shape is the primary identifying characteristic of a plane. It is determined by the contour of the line forming the edges of a plane. Because our perception of shape can be distorted by perspective foreshortening, we see the true shape of a plane only when we view it frontally.

The supplementary properties of a plane—its surface color, pattern, and texture—affect its visual weight and stability.



In the composition of a visual construction, a plane serves to define the limits or boundaries of a volume. If architecture as a visual art deals specifically with the formation of three-dimensional volumes of mass and space, then the plane should be regarded as a key element in the vocabulary of architectural design.

Planes in architecture define three-dimensional volumes of mass and space. The properties of each plane—size, shape, color, texture —as well as their spatial relationship to one another ultimately determine the visual attributes of the form they define and the qualities of the space they enclose.



In architectural design, we manipulate three generic types of planes:

Overhead Plane

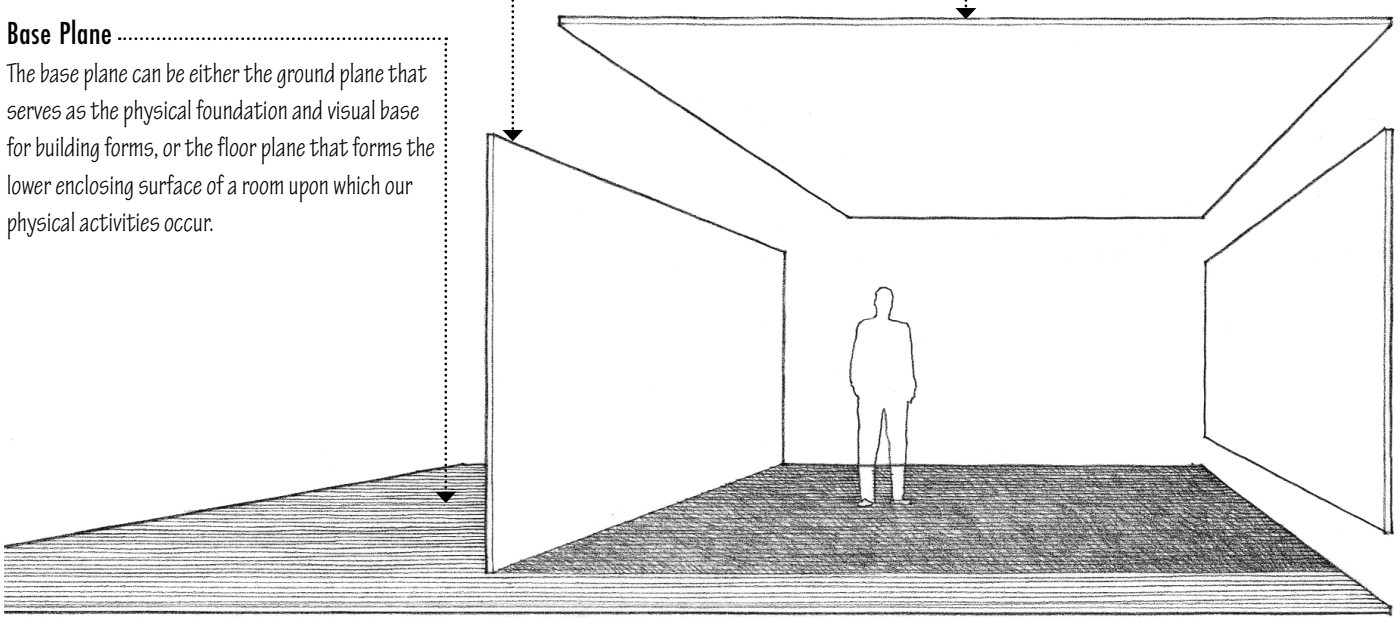
The overhead plane can be either the roof plane that spans and shelters the interior spaces of a building from the climatic elements, or the ceiling plane that forms the upper enclosing surface of a room.

Wall Plane

The wall plane, because of its vertical orientation, is active in our normal field of vision and vital to the shaping and enclosure of architectural space.

Base Plane

The base plane can be either the ground plane that serves as the physical foundation and visual base for building forms, or the floor plane that forms the lower enclosing surface of a room upon which our physical activities occur.

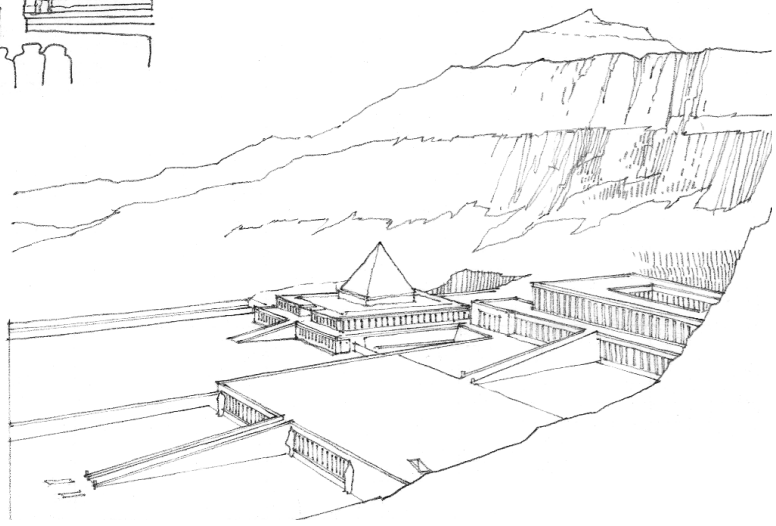


PLANAR ELEMENTS

The ground plane ultimately supports all architectural construction. Along with climate and other environmental conditions of a site, the topographical character of the ground plane influences the form of the building that rises from it. The building can merge with the ground plane, rest firmly on it, or be elevated above it.

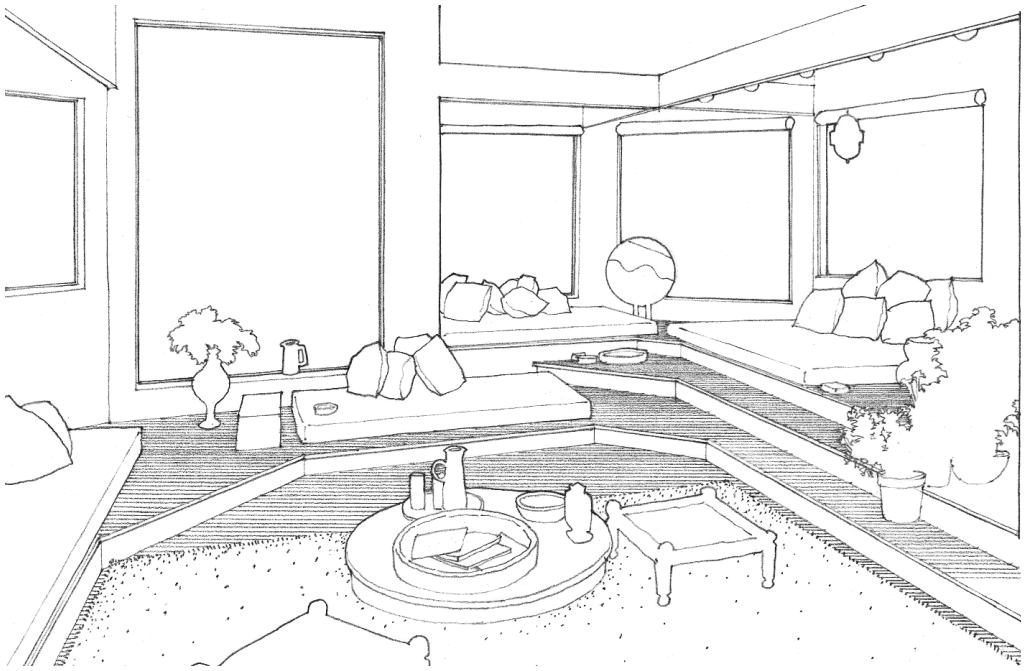
The ground plane itself can be manipulated as well to establish a podium for a building form. It can be elevated to honor a sacred or significant place; bermed to define outdoor spaces or buffer against undesirable conditions; carved or terraced to provide a suitable platform on which to build; or stepped to allow changes in elevation to be easily traversed.

Scala de Spagna (Spanish Steps), Rome, 1721–1725.
Alessandro Specchi designed this civic project to connect the Piazza di Spagna with SS. Trinita de' Monti; completed by Francesco de Sanctis.



Mortuary Temple of Queen Hatshepsut,
Dêr el-Bahari, Thebes, 1511–1480 B.C., Senmut.
Three terraces, approached by ramps, rise toward the base of the cliffs where the chief sanctuary is cut deep into the rock.

Machu Picchu, an ancient Incan city established c.1500 in the Andes Mountains on a saddle between two peaks, 8000 ft. above the Urubamba River in south-central Peru.

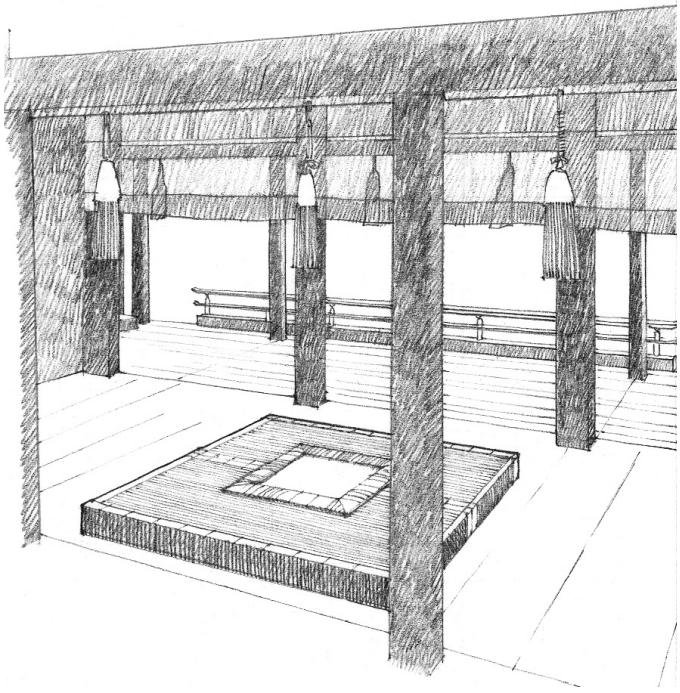


Sitting Area, **Lawrence House**, Sea Ranch, California, 1966, MLTW

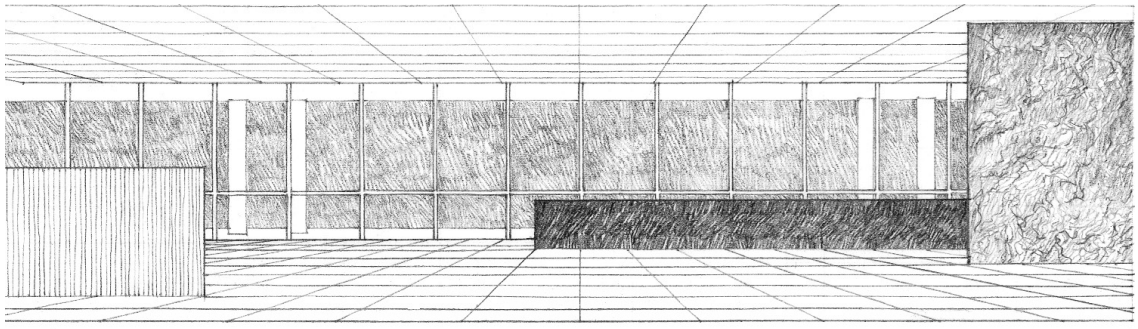
The floor plane is the horizontal element that sustains the force of gravity as we move around and place objects for our use on it. It may be a durable covering of the ground plane or a more artificial, elevated plane spanning the space between its supports. In either case, the texture and density of the flooring material influences both the acoustical quality of a space and how we feel as we walk across its surface.

While the pragmatic, supportive nature of the floor plane limits the extent to which it can be manipulated, it is nonetheless an important element of architectural design. Its shape, color, and pattern determine to what degree it defines spatial boundaries or serves as a unifying element for the different parts of a space.

Like the ground plane, the form of a floor plane can be stepped or terraced to break the scale of a space down to human dimensions and create platforms for sitting, viewing, or performing. It can be elevated to define a sacred or honorific place. It can be rendered as a neutral ground against which other elements in a space are seen as figures.

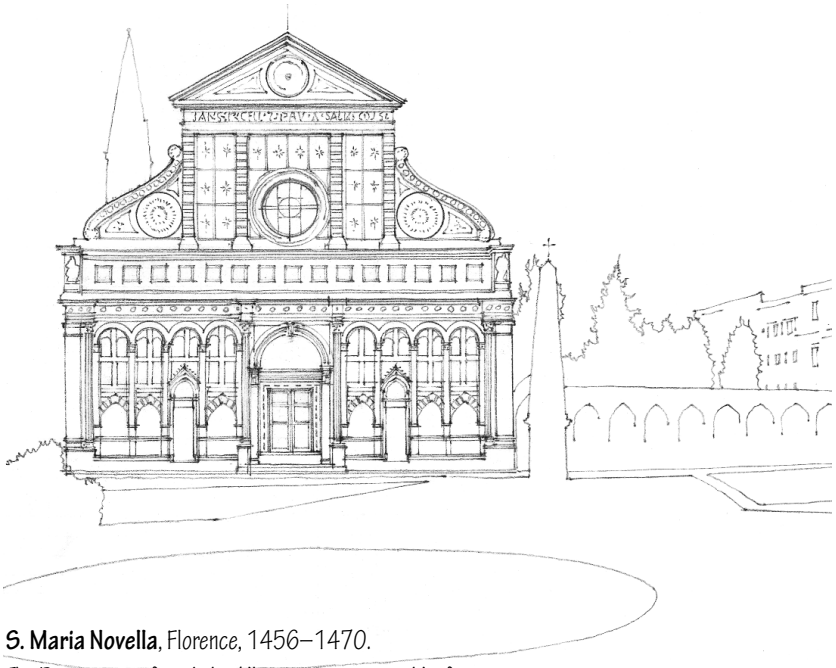


Emperor's Seat, Imperial Palace, Kyoto, Japan, 17th century



Bacardi Office Building (Project), Santiago de Cuba, 1958, Mies van der Rohe

PLANAR ELEMENTS

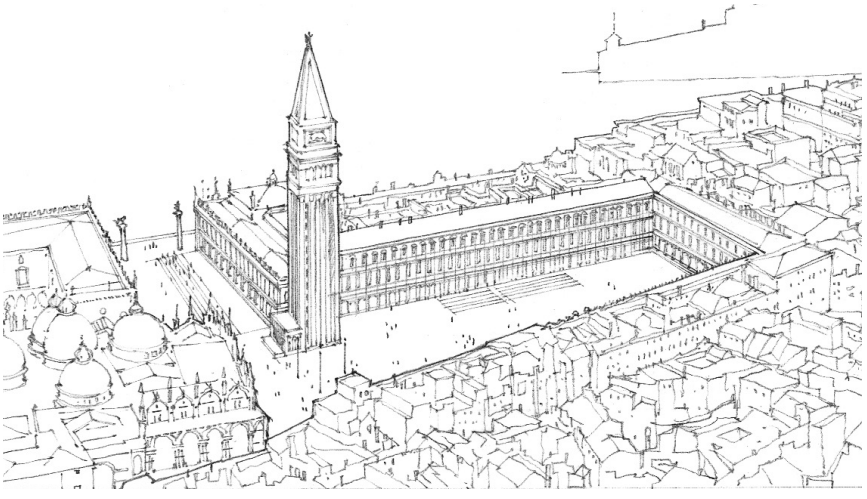


S. Maria Novella, Florence, 1456–1470.
The Renaissance facade by Alberti presents a public face to a square.

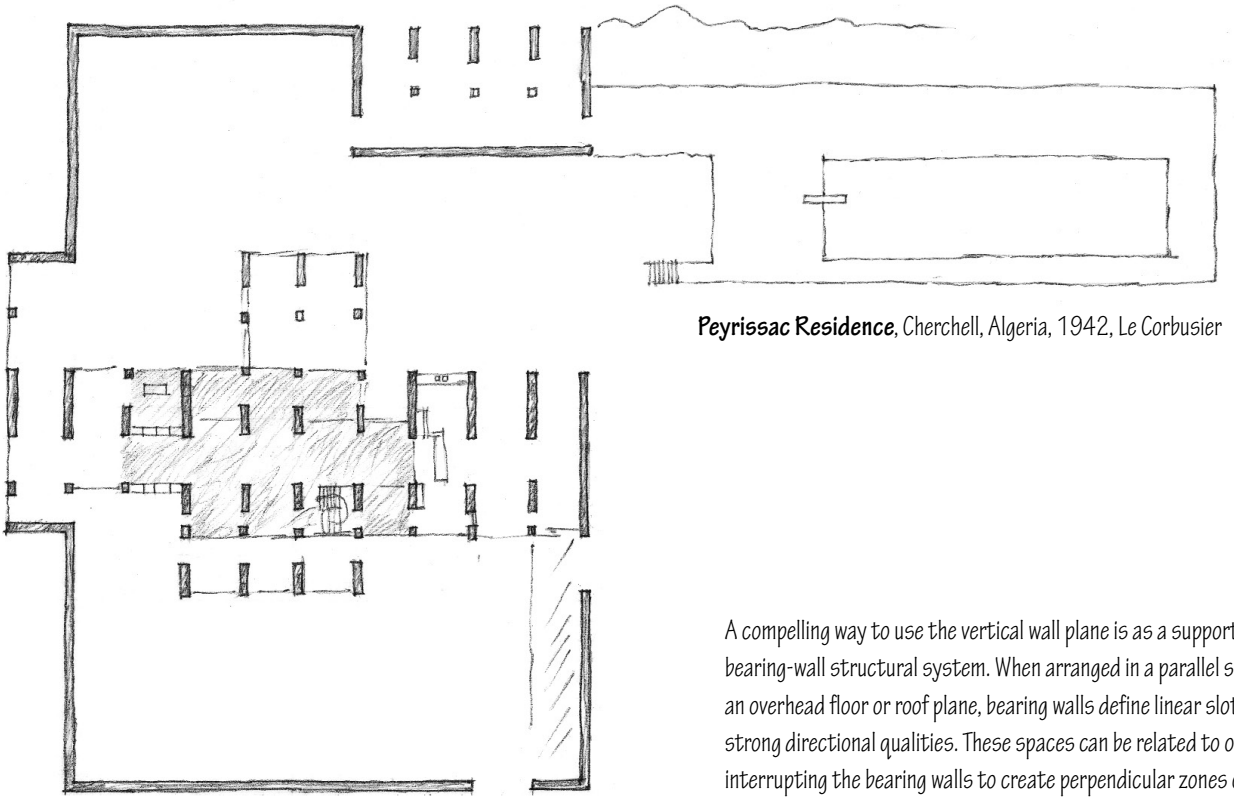
Uffizi Palace, 1560–1565, Giorgio Vasari.
This Florentine street defined by the two wings of the Uffizi Palace links the Piazza della Signoria with the River Arno.

Exterior wall planes isolate a portion of space to create a controlled interior environment. Their construction provides both privacy and protection from the climatic elements for the interior spaces of a building, while openings within or between their boundaries reestablish a connection with the exterior environment. As exterior walls mold interior space, they simultaneously shape exterior space and describe the form, massing, and image of a building in space.

As a design element, the plane of an exterior wall can be articulated as the front or primary facade of a building. In urban situations, these facades serve as walls that define courtyards, streets, and such public gathering places as squares and marketplaces.

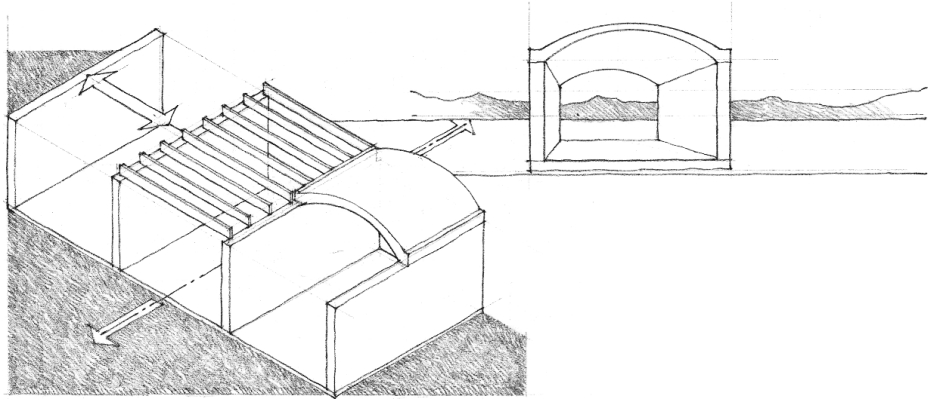


Piazza San Marco, Venice.
The continuous facades of buildings form the "walls" of the urban space.



Peyrissac Residence, Cherchell, Algeria, 1942, Le Corbusier

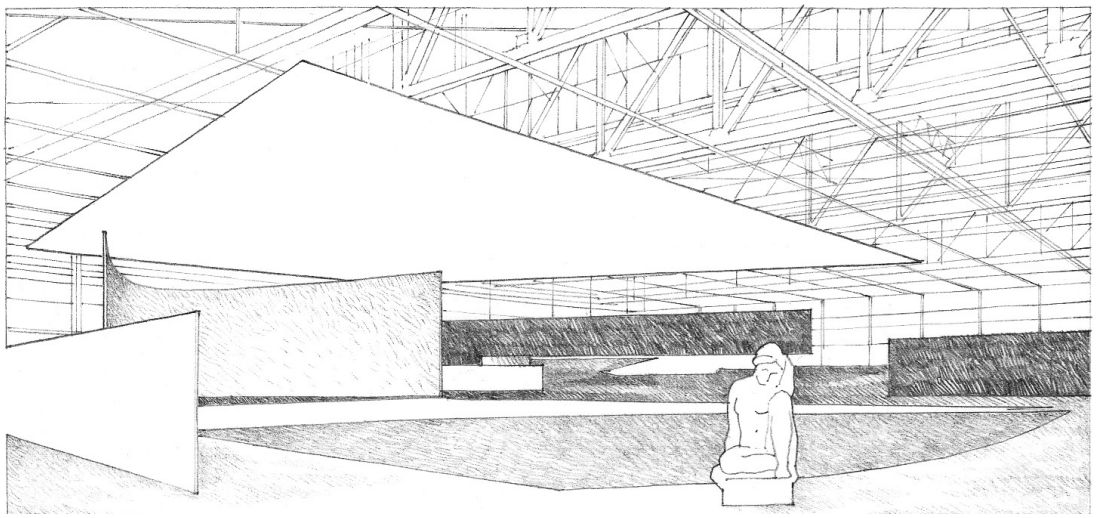
A compelling way to use the vertical wall plane is as a supporting element in the bearing-wall structural system. When arranged in a parallel series to support an overhead floor or roof plane, bearing walls define linear slots of space with strong directional qualities. These spaces can be related to one another only by interrupting the bearing walls to create perpendicular zones of space.



Country House in Brick (Project), 1923, Mies van der Rohe

In the project to the right, freestanding brick bearing walls, together with L-shaped and T-shaped configurations of planes, create an interlocking series of spaces.

PLANAR ELEMENTS

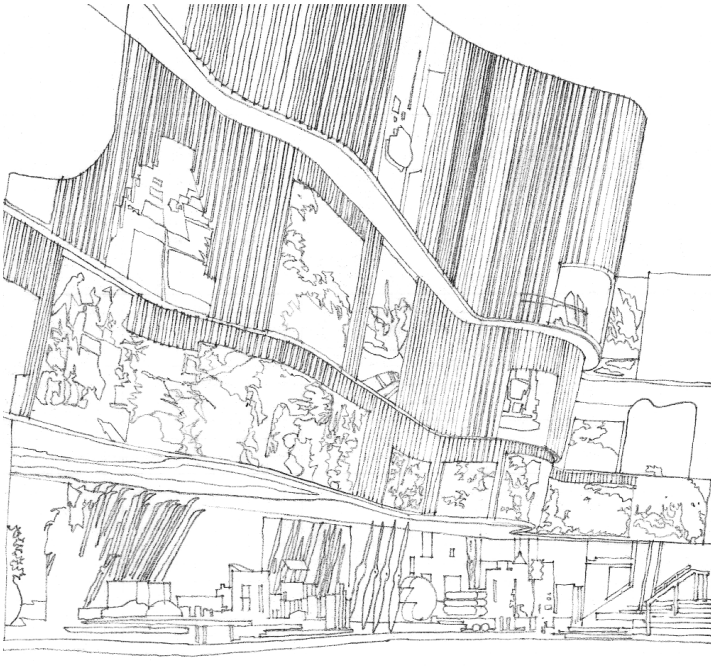


Concert Hall (Project), 1942, Mies van der Rohe

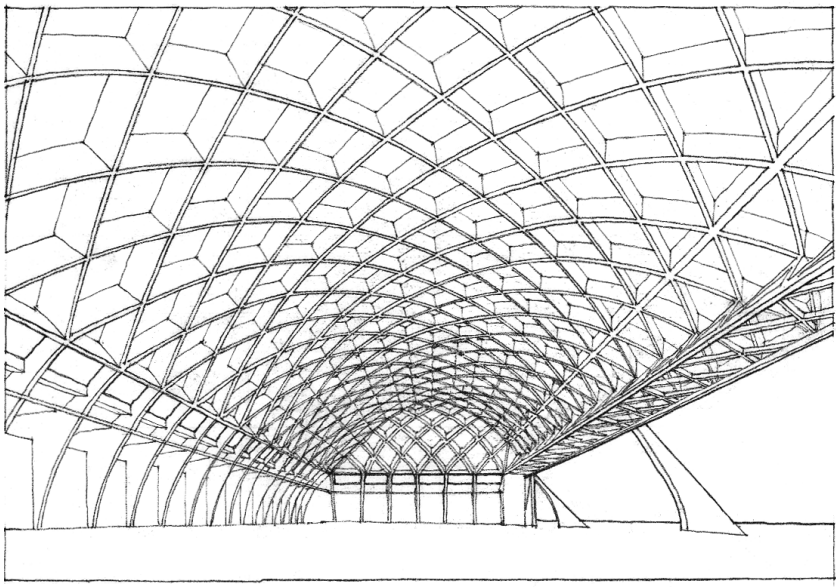
Interior wall planes govern the size and shape of the internal spaces or rooms within a building. Their visual properties, their relationship to one another, and the size and distribution of openings within their boundaries determine both the quality of the spaces they define and the degree to which adjoining spaces relate to one another.

As a design element, a wall plane can merge with the floor or ceiling plane, or be articulated as an element isolated from adjacent planes. It can be treated as a passive or receding backdrop for other elements in the space, or it can assert itself as a visually active element within a room by virtue of its form, color, texture, or material.

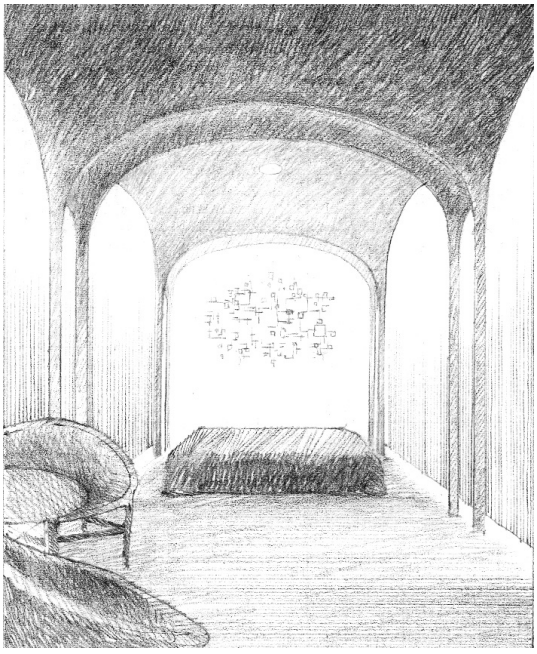
While walls provide privacy for interior spaces and serve as barriers that limit our movement, doorways and windows reestablish continuity with neighboring spaces and allow the passage of light, heat, and sound. As they increase in size, these openings begin to erode the natural sense of enclosure walls provide. Views seen through the openings become part of the spatial experience.



Finnish Pavilion, New York World's Fair, 1939, Alvar Aalto



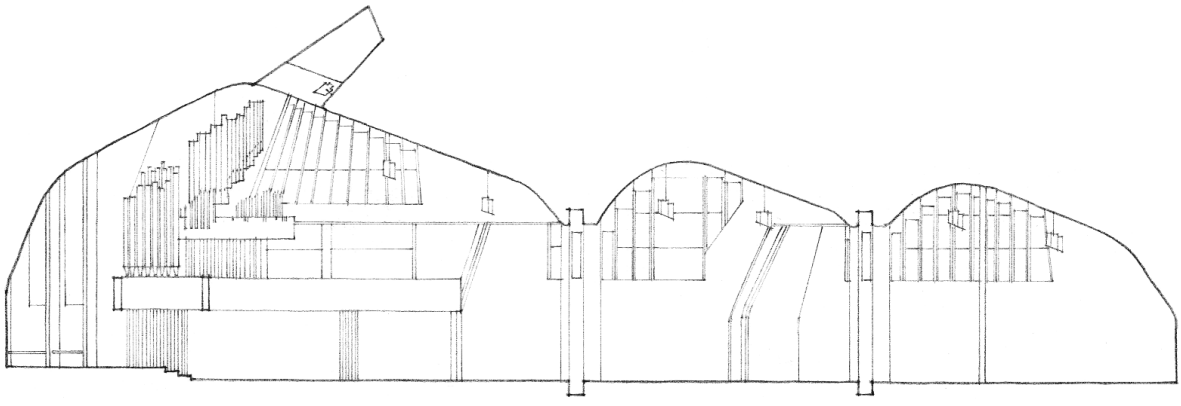
Hangar, Design I, 1935, Pier Luigi Nervi.
The lamella structure expresses the way forces are resolved and channeled down to the roof supports.



Brick House, New Canaan, Connecticut, 1949, Philip Johnson. The detached vaulted ceiling plane appears to float above the bed.

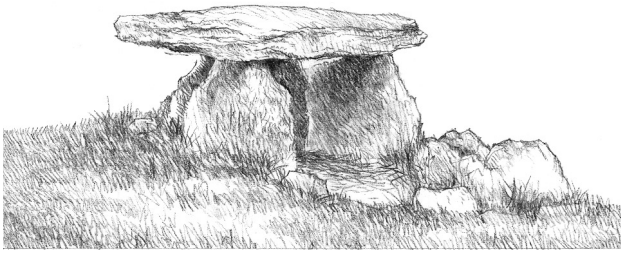
While we walk on a floor and have physical contact with walls, the ceiling plane is usually out of our reach and is almost always a purely visual event in a space. It may be the underside of an overhead floor or roof plane and express the form of its structure as it spans the space between its supports, or it may be suspended as the upper enclosing surface of a room or hall.

As a detached lining, the ceiling plane can symbolize the sky vault or be the primary sheltering element that unifies the different parts of a space. It can serve as a repository for frescoes and other means of artistic expression or be treated simply as a passive or receding surface. It can be raised or lowered to alter the scale of a space or to define spatial zones within a room. Its form can be manipulated to control the quality of light or sound within a space.



Church at Vuoksenniska, Imatra, Finland, 1956, Alvar Aalto.
The form of the ceiling plane defines a progression of spaces and enhances their acoustical quality.

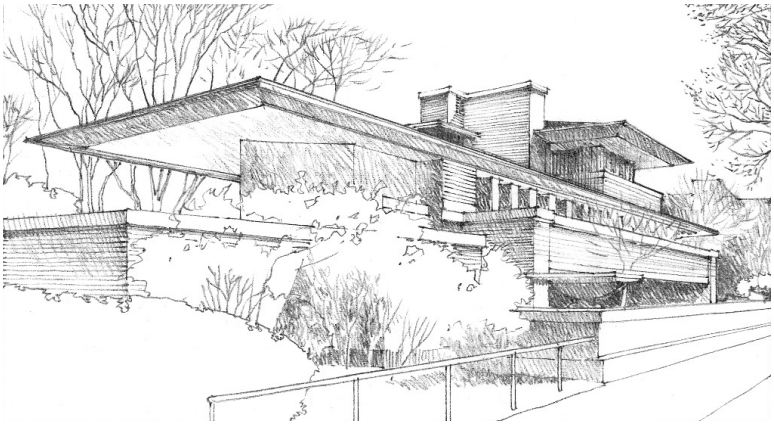
PLANAR ELEMENTS



Dolmen, a prehistoric monument consisting of two or more large upright stones supporting a horizontal stone slab, found especially in Britain and France and usually regarded as a burial place for an important person.

The roof plane is the essential sheltering element that protects the interior of a building from the climatic elements. The form and geometry of its structure is established by the manner in which it spans across space to bear on its supports and slopes to shed rain and melting snow. As a design element, the roof plane is significant because of the impact it can have on the form and silhouette of a building within its setting.

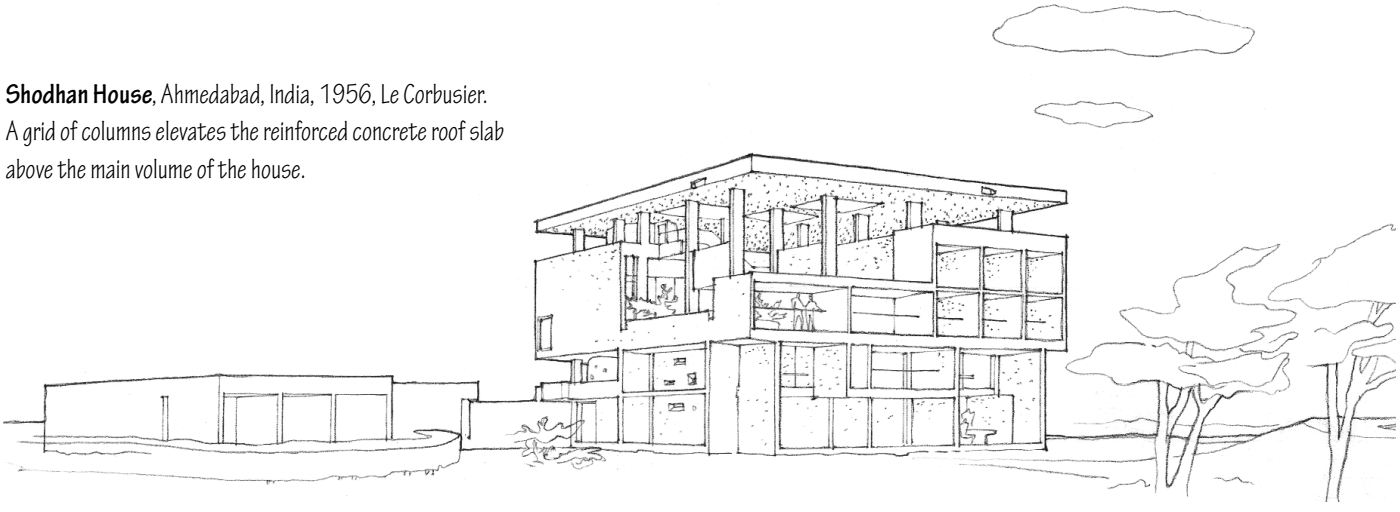
The roof plane can be hidden from view by the exterior walls of a building or merge with the walls to emphasize the volume of the building mass. It can be expressed as a single sheltering form that encompasses a variety of spaces beneath its canopy, or comprise a number of hats that articulate a series of spaces within a single building.

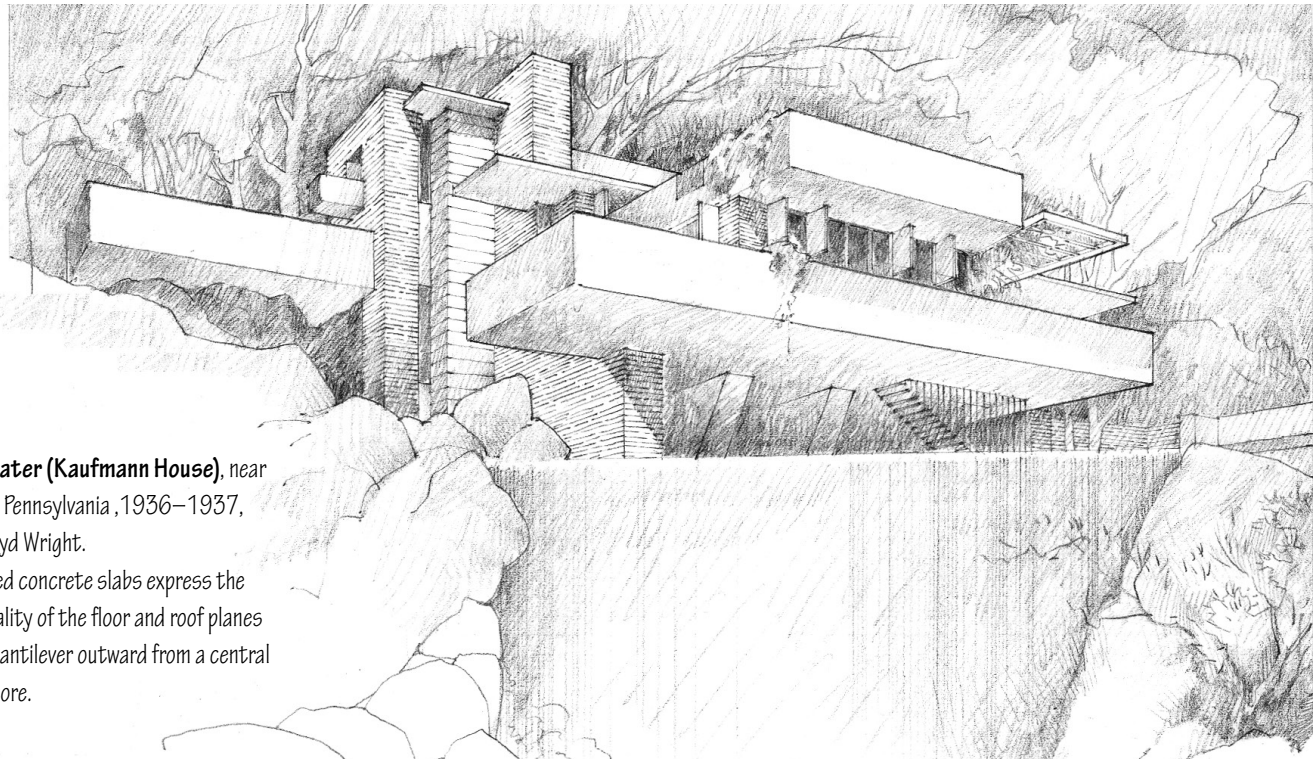


Robie House, Chicago, 1909, Frank Lloyd Wright.
The low sloping roof planes and broad overhangs are characteristic of the Prairie School of Architecture.

A roof plane can extend outward to form overhangs that shield door and window openings from sun or rain, or continue downward further still to relate itself more closely to the ground plane. In warm climates, it can be elevated to allow cooling breezes to flow across and through the interior spaces of a building.

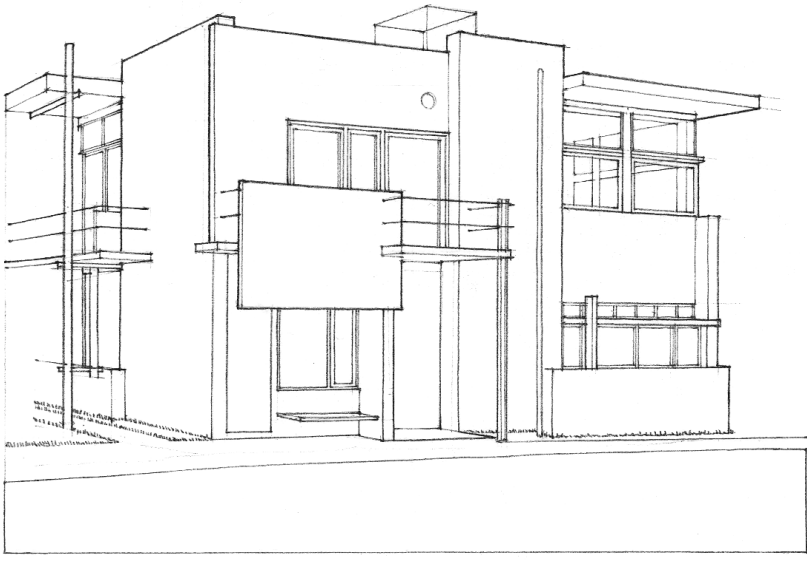
Shodhan House, Ahmedabad, India, 1956, Le Corbusier.
A grid of columns elevates the reinforced concrete roof slab above the main volume of the house.





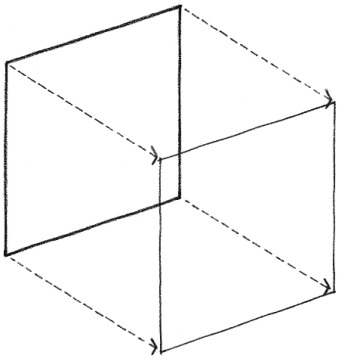
Fallingwater (Kaufmann House), near Ohiopyle, Pennsylvania ,1936–1937, Frank Lloyd Wright.
Reinforced concrete slabs express the horizontality of the floor and roof planes as they cantilever outward from a central vertical core.

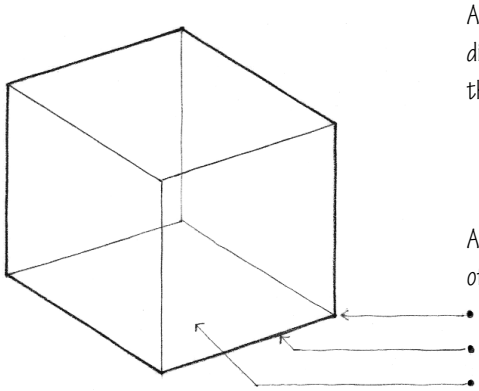
The overall form of a building can be endowed with a distinctly planar quality by carefully introducing openings that expose the edges of vertical and horizontal planes. These planes can be further differentiated and accentuated by changes in color, texture, or material.



Schröder House, Utrecht, 1924–1925, Gerrit Thomas Rietveld.
Asymmetrical compositions of simple rectangular forms and primary colors characterized the de Stijl School of Art and Architecture.

VOLUME

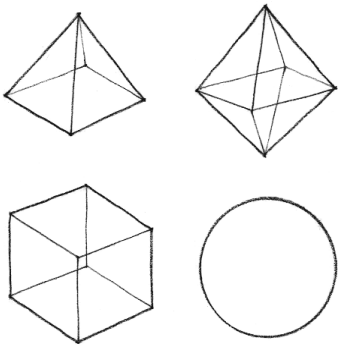




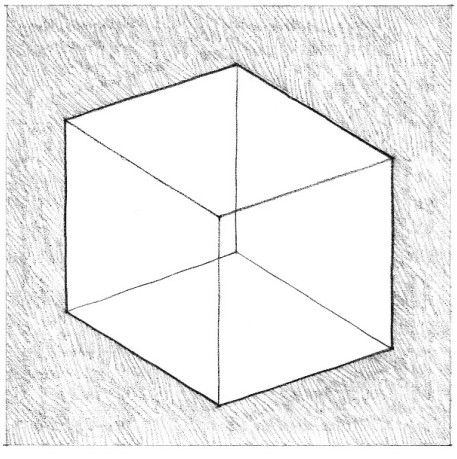
A plane extended in a direction other than its intrinsic direction becomes a volume. Conceptually, a volume has three dimensions: length, width, and depth.

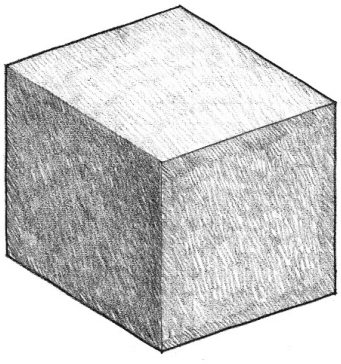
All volumes can be analyzed and understood to consist of:

- points or vertices where several planes come together
- lines or edges where two planes meet
- planes or surfaces that define the limits or boundaries of a volume

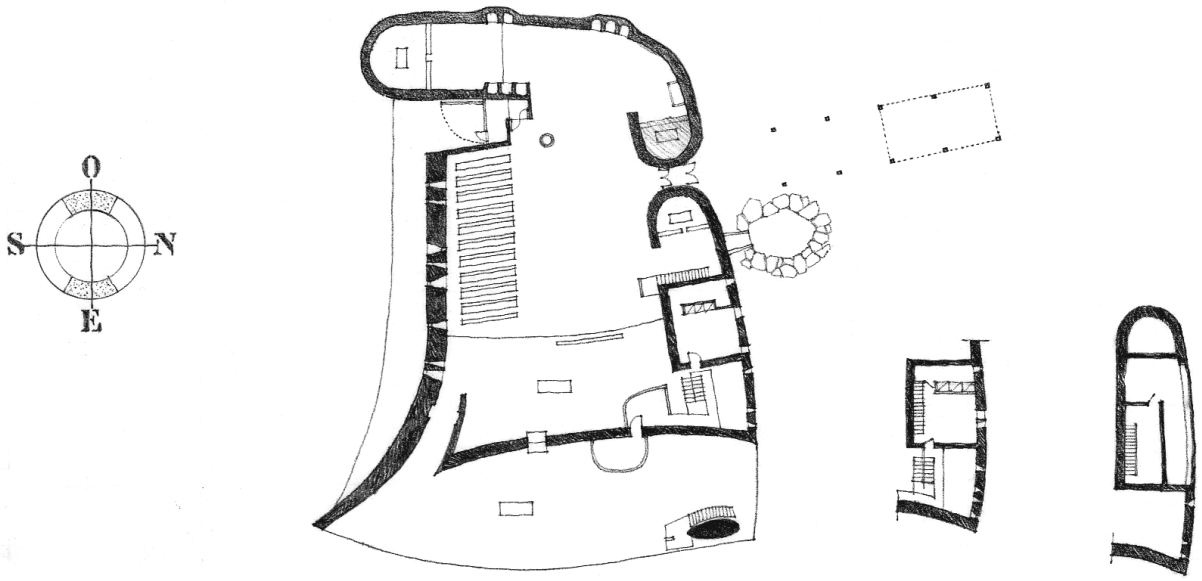


Form is the primary identifying characteristic of a volume. It is established by the shapes and interrelationships of the planes that describe the boundaries of the volume.



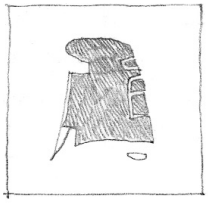


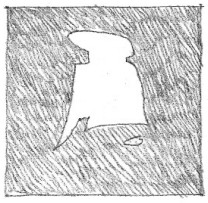
As the three-dimensional element in the vocabulary of architectural design, a volume can be either a solid—space displaced by mass—or a void—space contained or enclosed by planes.



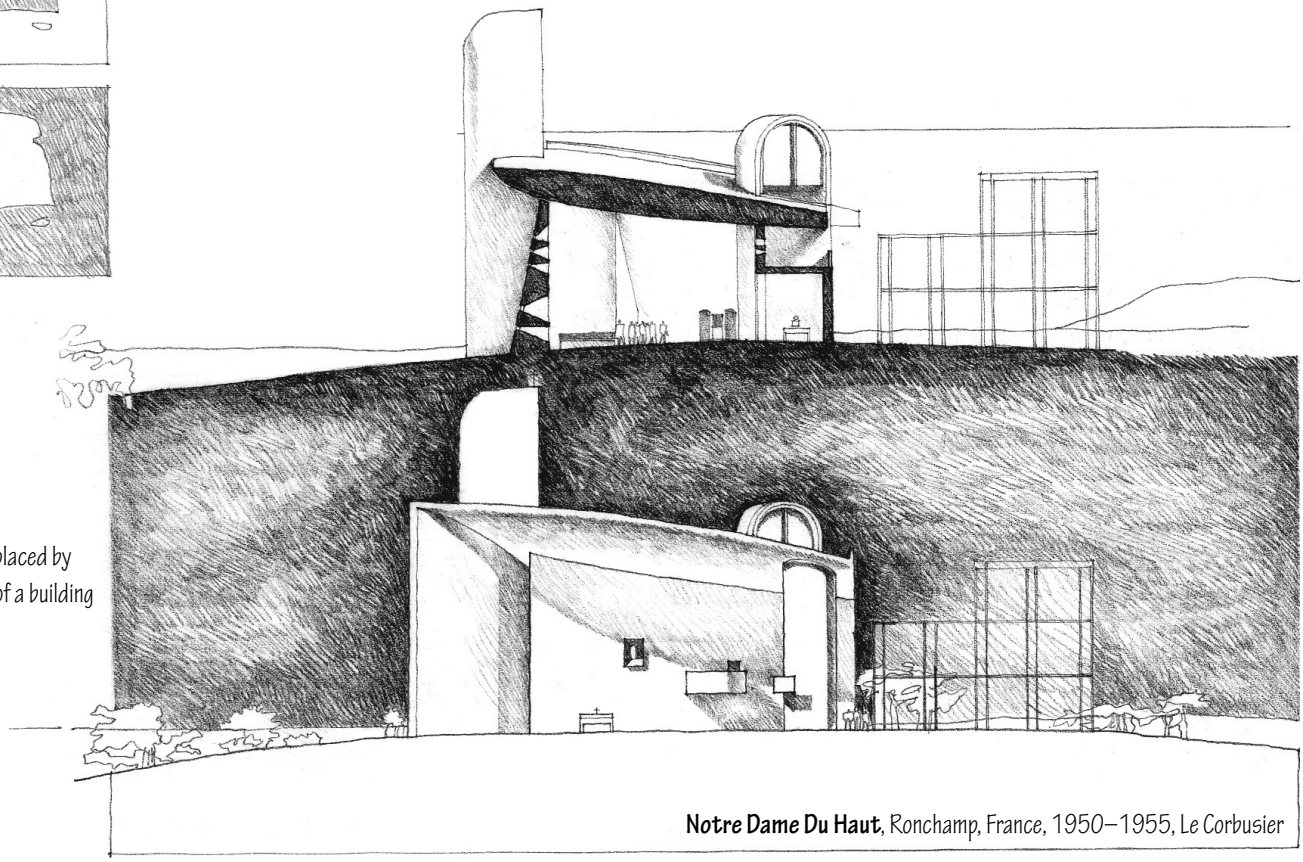
Plan and Section
Space defined by wall, floor, and ceiling or roof planes

In architecture, a volume can be seen to be either a portion of space contained and defined by wall, floor, and ceiling or roof planes, or a quantity of space displaced by the mass of a building. It is important to perceive this duality, especially when reading orthographic plans, elevations, and sections.





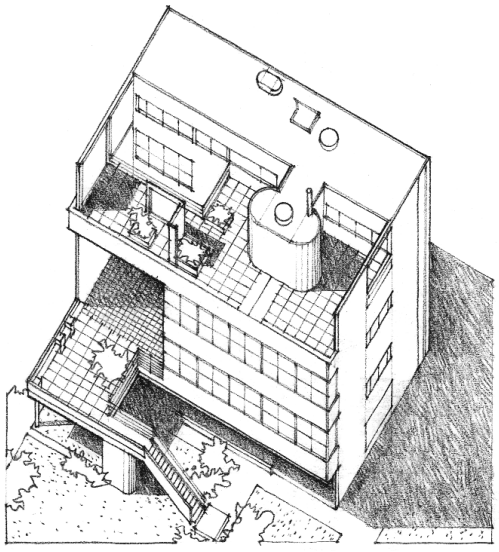
Elevation
Space displaced by the mass of a building



Notre Dame Du Haut, Ronchamp, France, 1950–1955, Le Corbusier

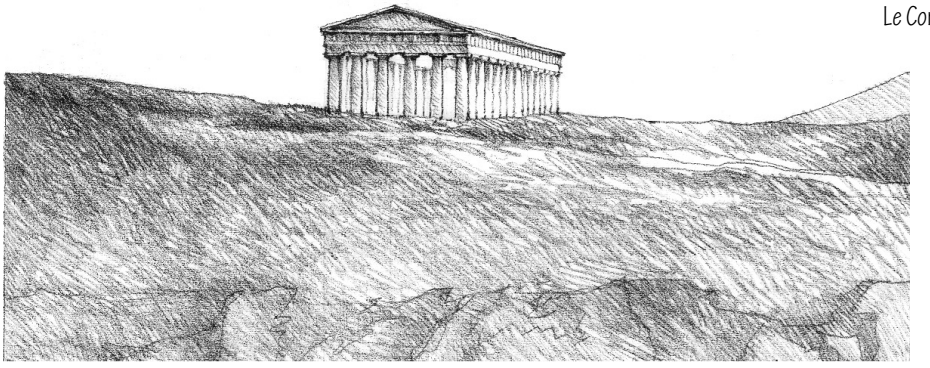
VOLUMETRIC ELEMENTS

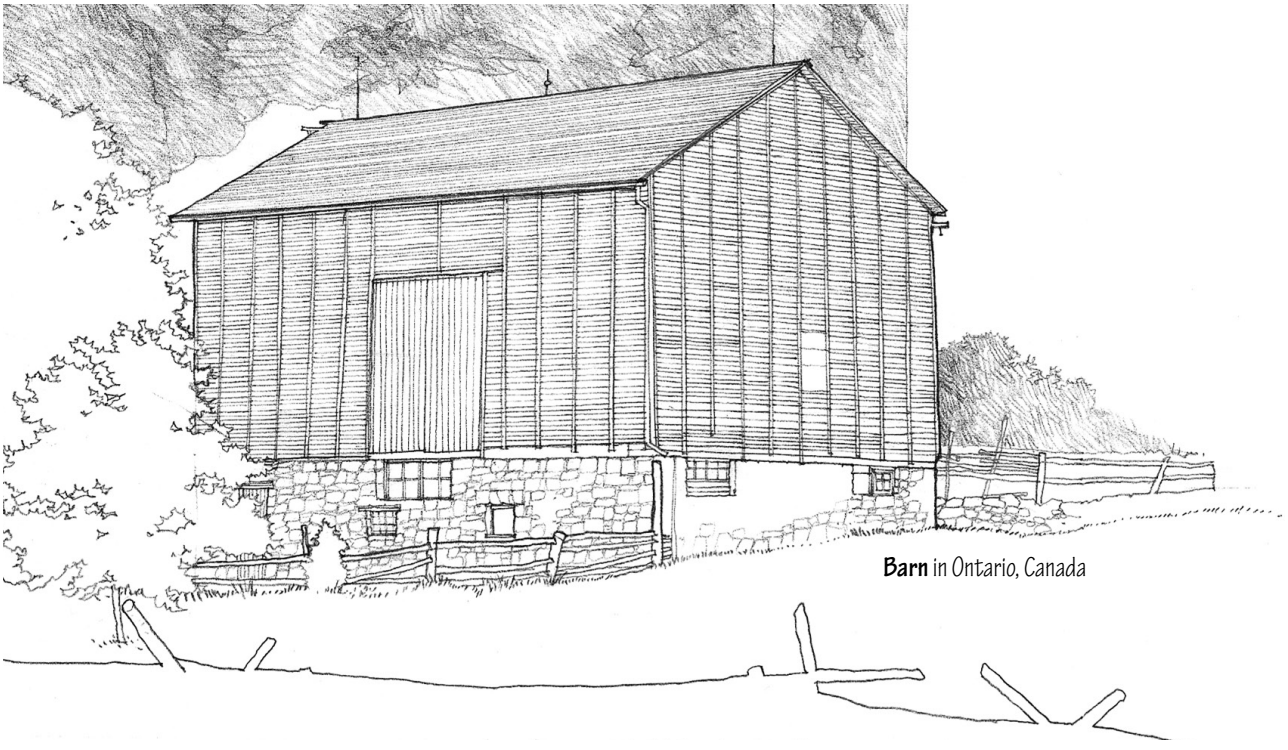
Building forms that stand as objects in the landscape can be read as occupying volumes in space.



Villa Garches, Vaucresson, France, 1926–1927, Le Corbusier

Doric Temple at Segesta, Sicily, c. 424–416 B.C.

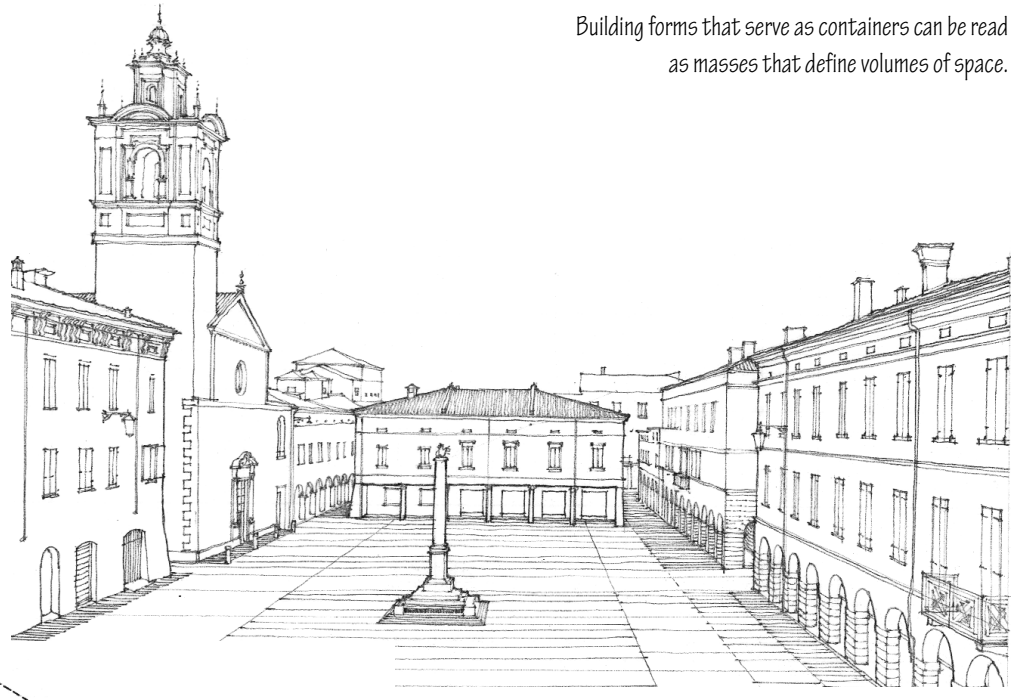




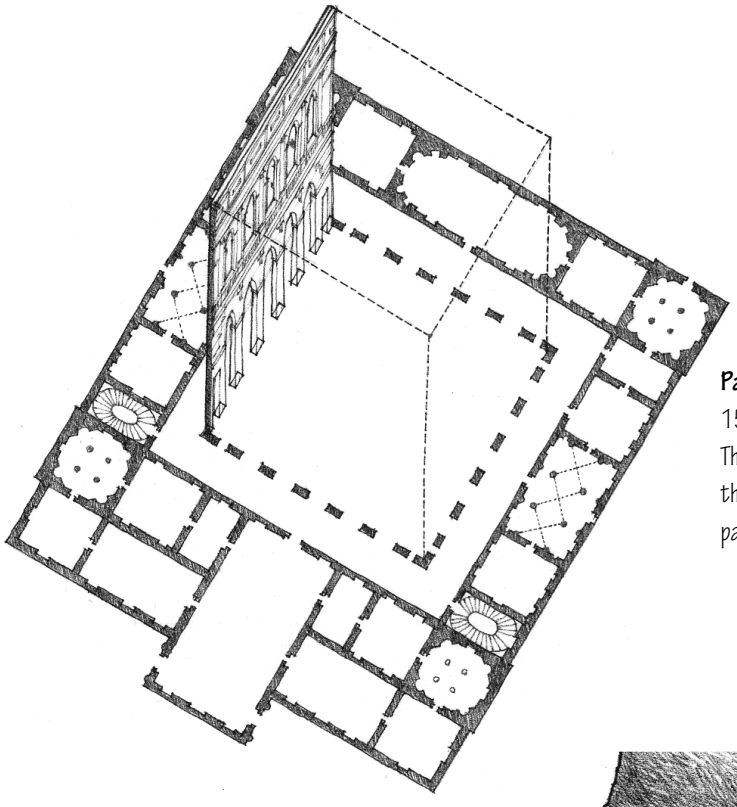
Barn in Ontario, Canada

VOLUMETRIC ELEMENTS

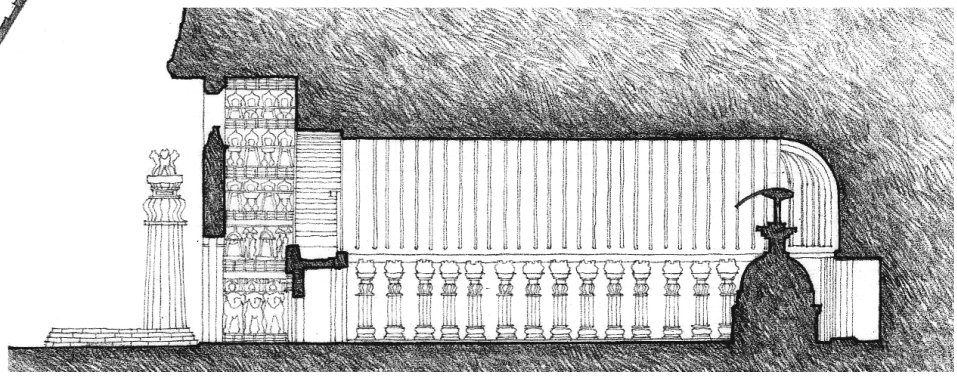
Building forms that serve as containers can be read as masses that define volumes of space.



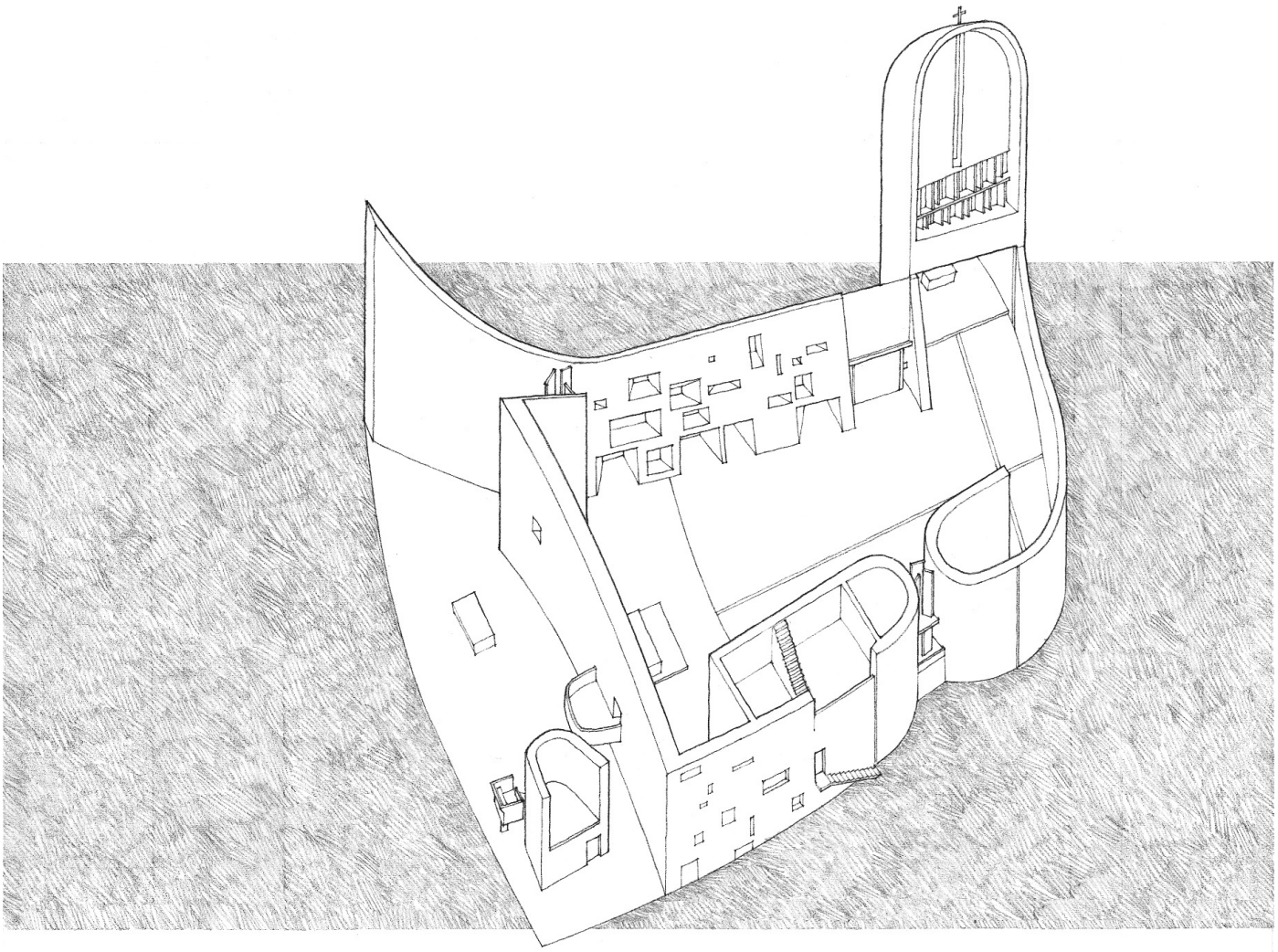
Piazza Maggiore, Sabbioneta, Italy.
A series of buildings enclose an urban square.



Palazzo Thiene, Vicenza, Italy,
1545, Andrea Palladio.
The interior rooms surround a cortile—
the principal courtyard of an Italian
palazzo.



Buddhist Chaitya Hall at Karli,
Maharashtra, India, A.D. 100–125.
The sanctuary is a volume of space carved
out of the mass of solid rock.



Notre Dame Du Haut, Ronchamp, France, 1950–1955, Le Corbusier

2
Form

"Architectural form is the point of contact between mass and space . . . Architectural forms, textures, materials, modulation of light and shade, color, all combine to inject a quality or spirit that articulates space. The quality of the architecture will be determined by the skill of the designer in using and relating these elements, both in the interior spaces and in the spaces around buildings."

Edmund N. Bacon
The Design of Cities
1974

Architecture: Form, Space, & Order, Fifth Edition. Francis D. K. Ching.
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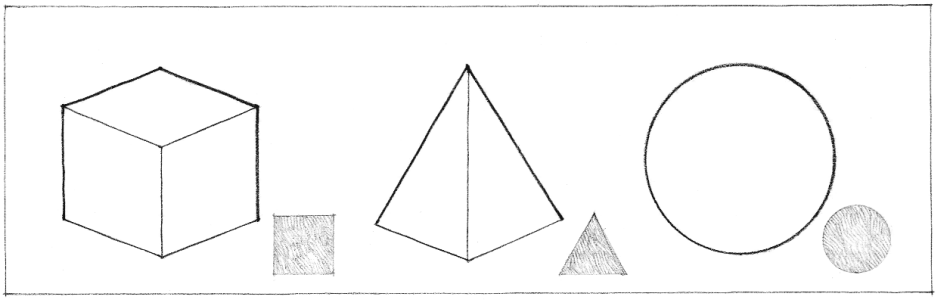
Companion Website: www.wiley.com/go/ching/architecturefso5e

FORM

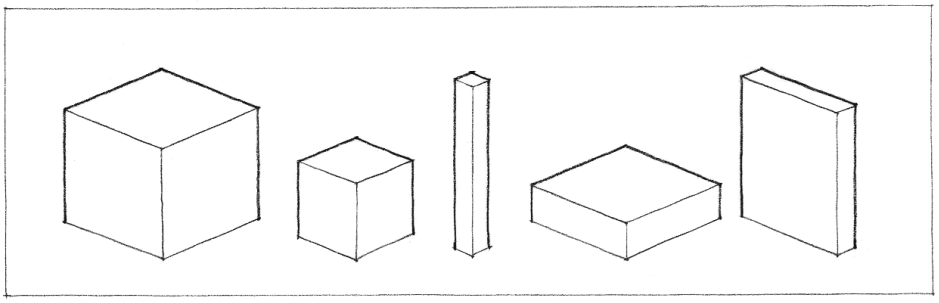
Form is an inclusive term that has several meanings. It may refer to an external appearance that can be recognized, as that of a chair or the human body that sits in it. It may also allude to a particular condition in which something acts or manifests itself, as when we speak of water in the form of ice or steam. In art and design, we often use the term to denote the formal structure of a work—the manner of arranging and coordinating the elements and parts of a composition so as to produce a coherent image.

In the context of this study, form refers to both internal structure and external outline and the principle that gives unity to the whole. While form often includes a sense of three-dimensional mass or volume, shape refers more specifically to the essential aspect of form that governs its appearance—the configuration or relative disposition of the lines or contours that delimit a figure or form.

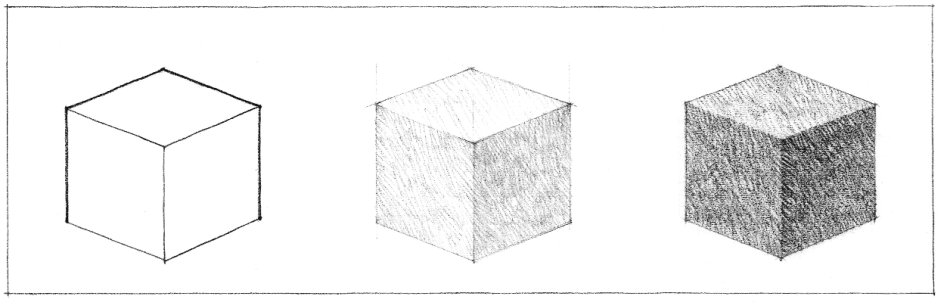


Shape The characteristic outline or surface configuration of a particular form. Shape is the principal aspect by which we identify and categorize forms.

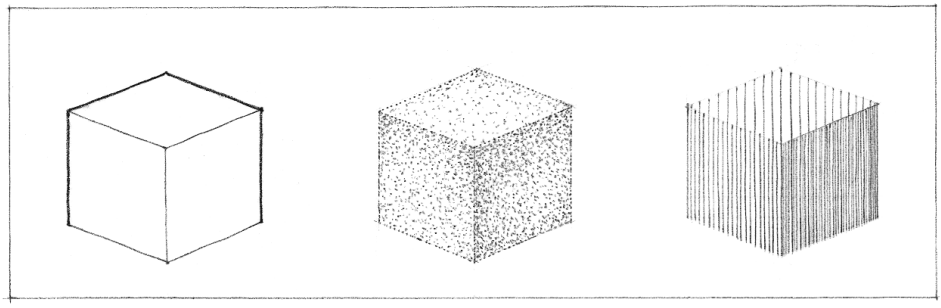
In addition to shape, forms have visual properties of:



Size The physical dimensions of length, width, and depth of a form. While these dimensions determine the proportions of a form, its scale is determined by its size relative to other forms in its context.



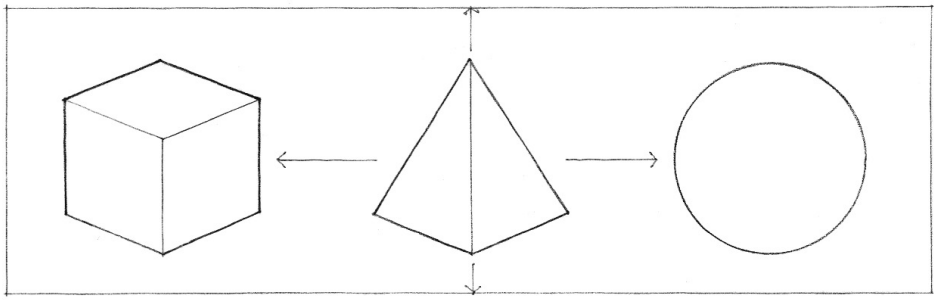
Color A phenomenon of light and visual perception that may be described in terms of an individual's perception of hue, saturation, and tonal value. Color is the attribute that most clearly distinguishes a form from its environment. It also affects the visual weight of a form.



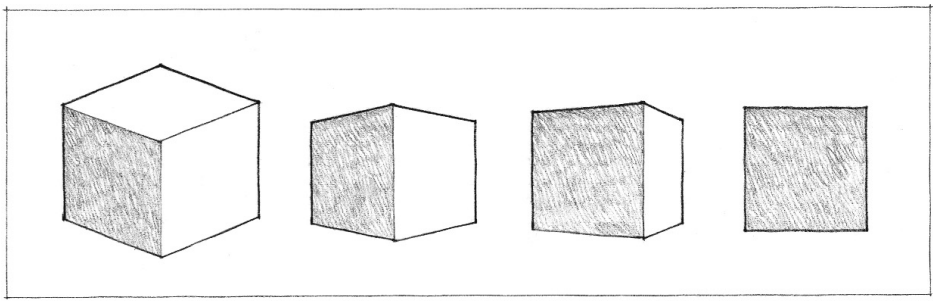
Texture The visual and especially tactile quality given to a surface by the size, shape, arrangement, and proportions of the parts. Texture also determines the degree to which the surfaces of a form reflect or absorb incident light.

Forms also have relational properties that govern the pattern and composition of elements:

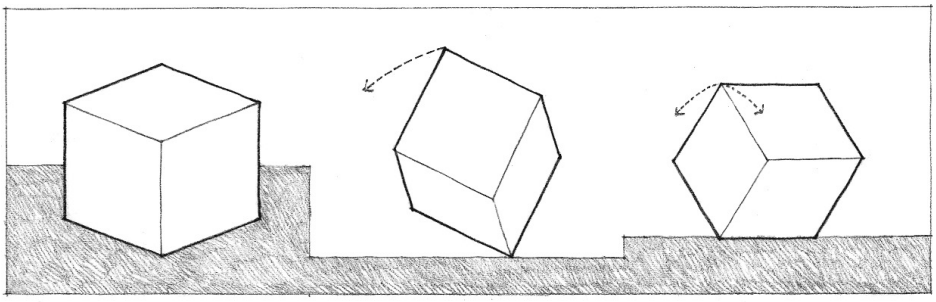
Position The location of a form relative to its environment or the visual field within which it is seen.

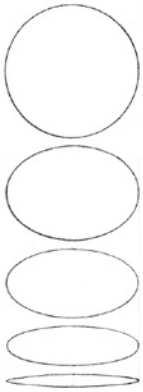


Orientation The direction of a form relative to the ground plane, the compass points, other forms, or to the person viewing the form.



Visual Inertia The degree of concentration and stability of a form. The visual inertia of a form depends on its geometry as well as its orientation relative to the ground plane, the pull of gravity, and our line of sight.

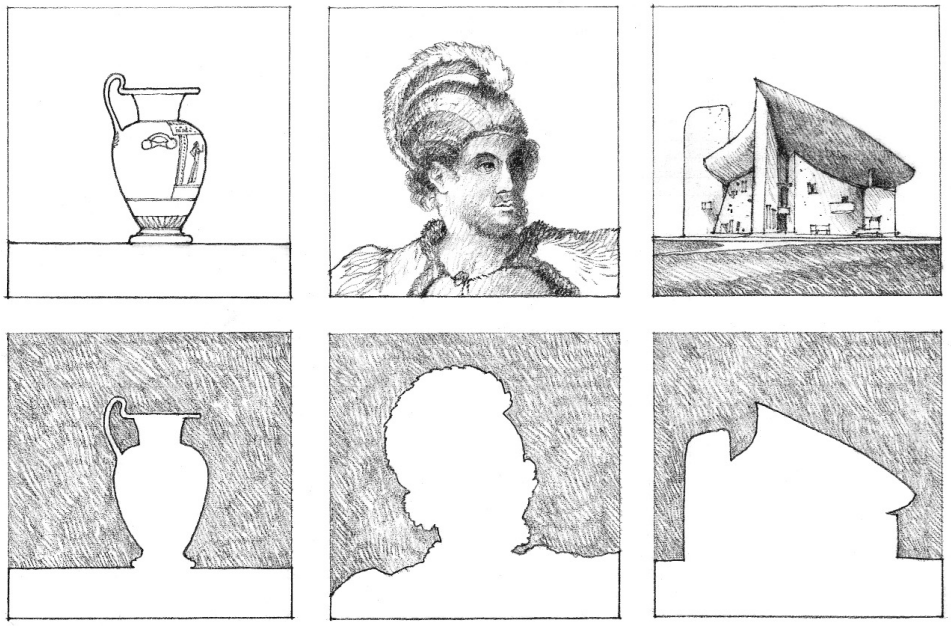




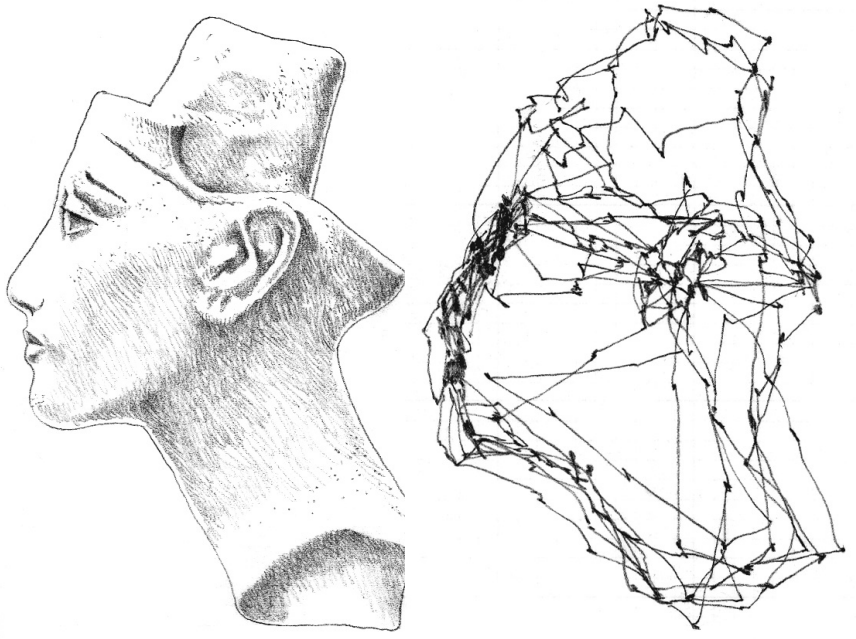
All of these properties of form are in reality affected by the conditions under which we view them.

- A changing perspective or angle of view presents different shapes or aspects of a form to our eyes.
- Our distance from a form determines its apparent size.
- The lighting conditions under which we view a form affects the clarity of its shape and structure.
- The visual field surrounding a form influences our ability to read and identify it.

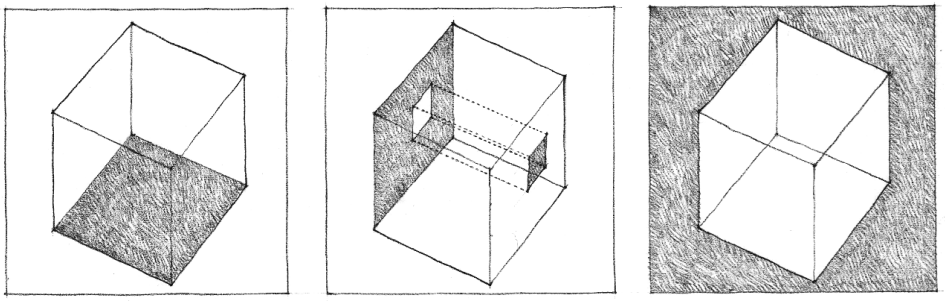
SHAPE



Shape refers to the characteristic outline of a plane figure or the surface configuration of a volumetric form. It is the primary means by which we recognize, identify, and categorize particular figures and forms. Our perception of shape depends on the degree of visual contrast that exists along the contour separating a figure from its ground or between a form and its field.



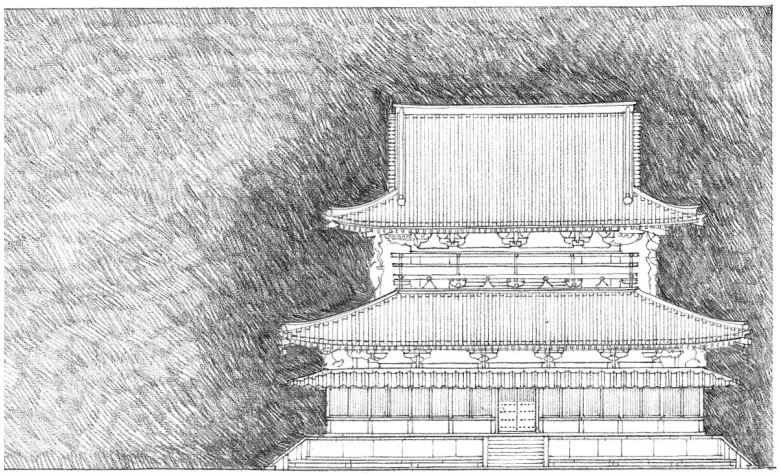
Bust of Queen Nefertiti
The pattern of eye movement of a person viewing the figure, from research by Alfred L. Yarbus of the Institute for Problems of Information Transmission in Moscow.



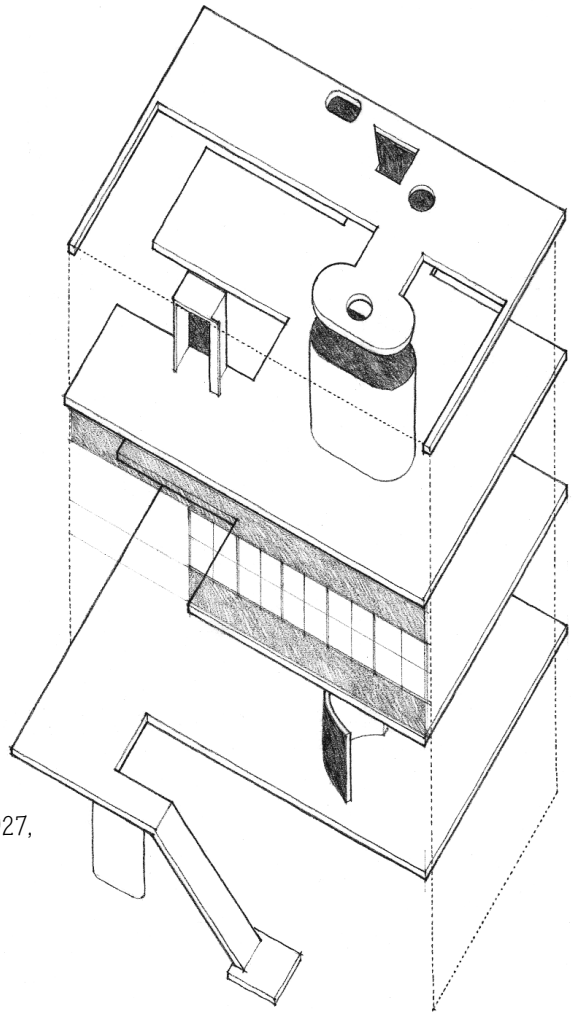
In architecture, we are concerned with the shapes of:

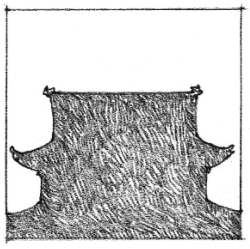
- Floor, wall, and ceiling planes that enclose space
- Door and window openings within a spatial enclosure
- Silhouettes and contours of building forms

These examples illustrate how shaping the juncture between mass and space expresses the manner in which the contours of a building mass rise from the ground plane and meet the sky.

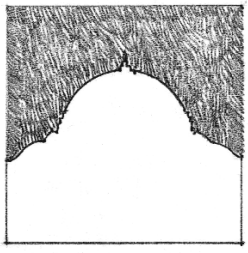


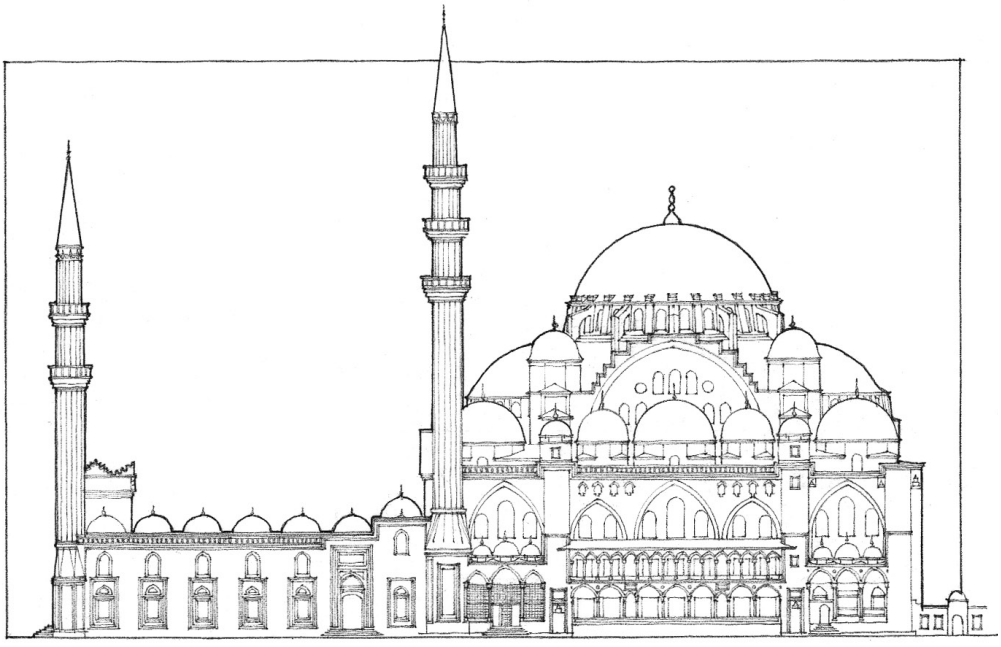
Central Pavilion, Horyu-Ji Temple, Nara, Japan, A.D. 607





Villa Garches, Vaucresson, France, 1926–1927, Le Corbusier. This architectural composition illustrates the interplay between the shapes of planar solids and voids.

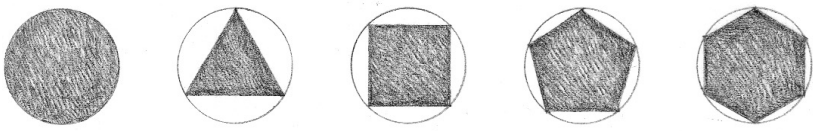




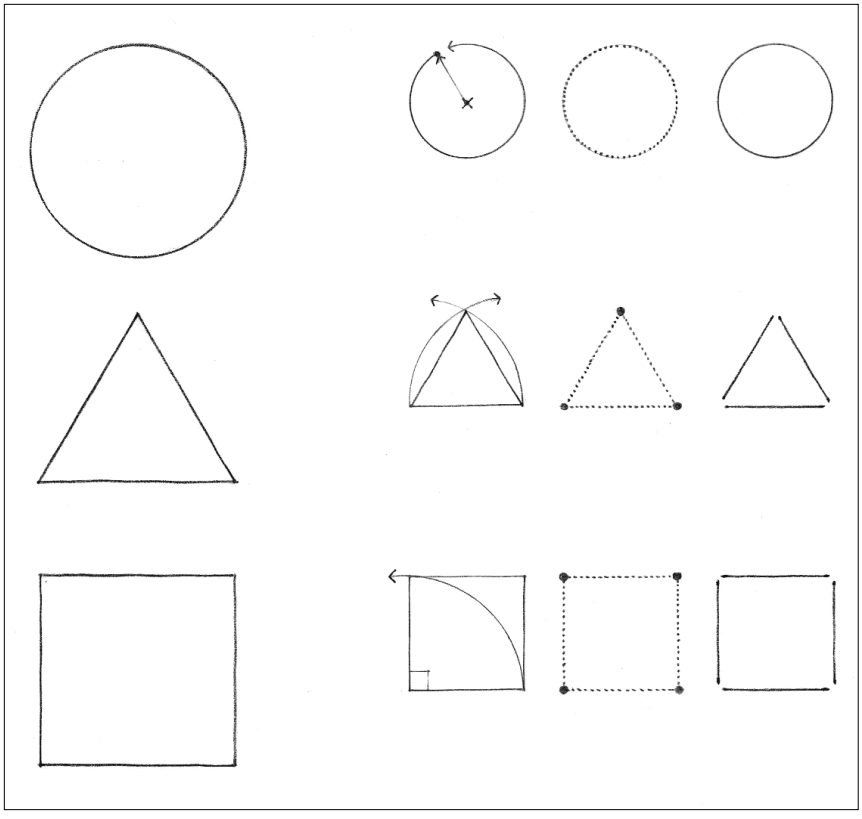
Suleymaniye Mosque,
Constantinople (Istanbul), 1551–1558,
Mimar Sinan

PRIMARY SHAPES

Gestalt psychology affirms that the mind will simplify the visual environment in order to understand it. Given any composition of forms, we tend to reduce the subject matter in our visual field to the simplest and most regular shapes. The simpler and more regular a shape is, the easier it is to perceive and understand.



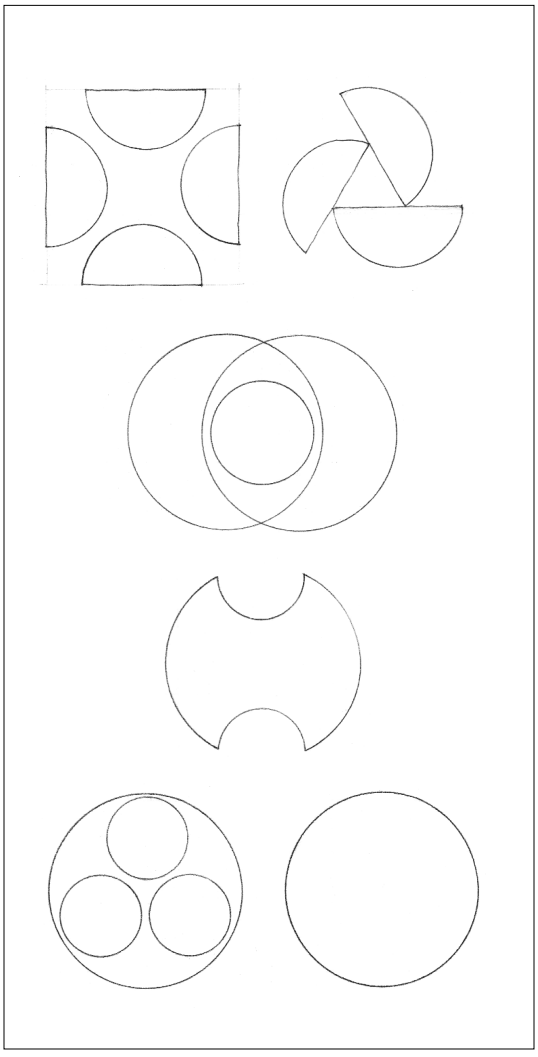
From geometry we know the regular shapes to be the circle, and the infinite series of regular polygons that can be inscribed within it. Of these, the most significant are the primary shapes: the circle, the triangle, and the square.



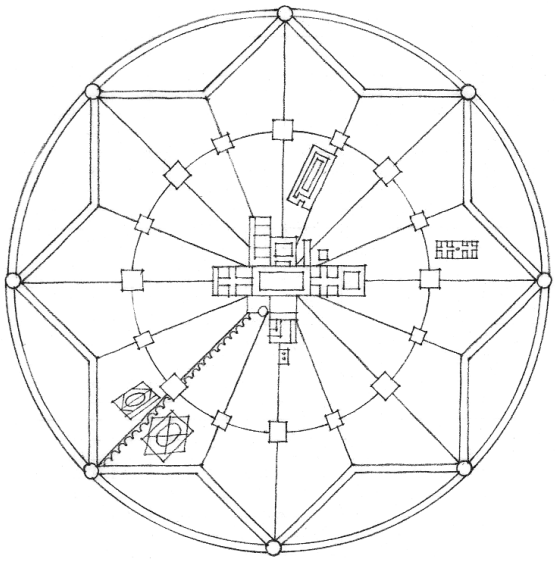
Circle A plane curve in which every point is equidistant from a fixed point within the curve

Triangle A plane figure bounded by three sides and having three angles

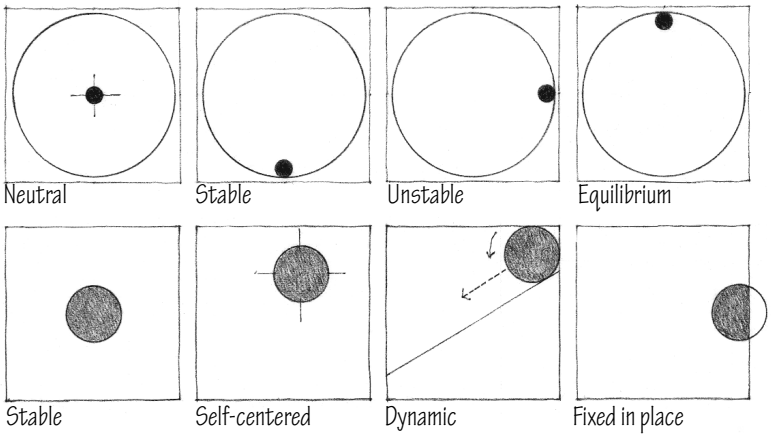
Square A plane figure having four equal sides and four right angles



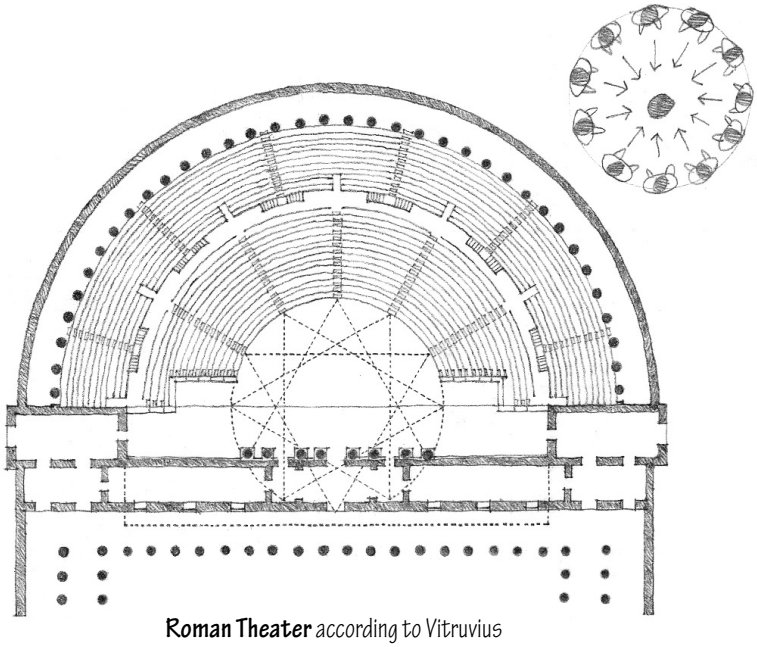
Compositions of circles and circular segments



Plan of the Ideal City of Sforzinda, 1464, Antonio Filarete

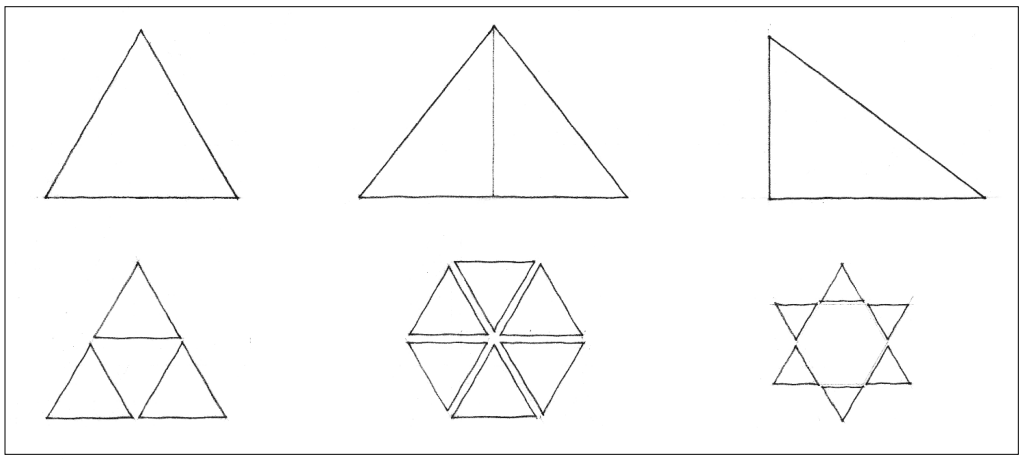


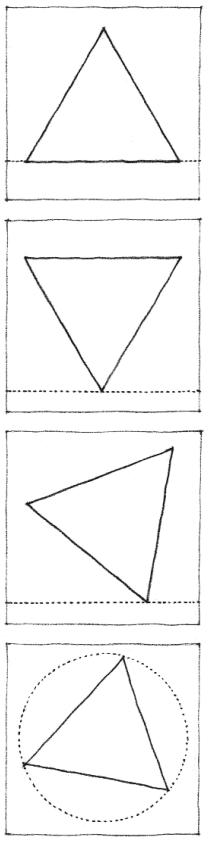
The circle is a centralized, introverted figure that is normally stable and self-centering in its environment. Placing a circle in the center of a field reinforces its inherent centrality. Associating it with straight or angular forms or placing an element along its circumference, however, can induce in the circle an apparent rotary motion.



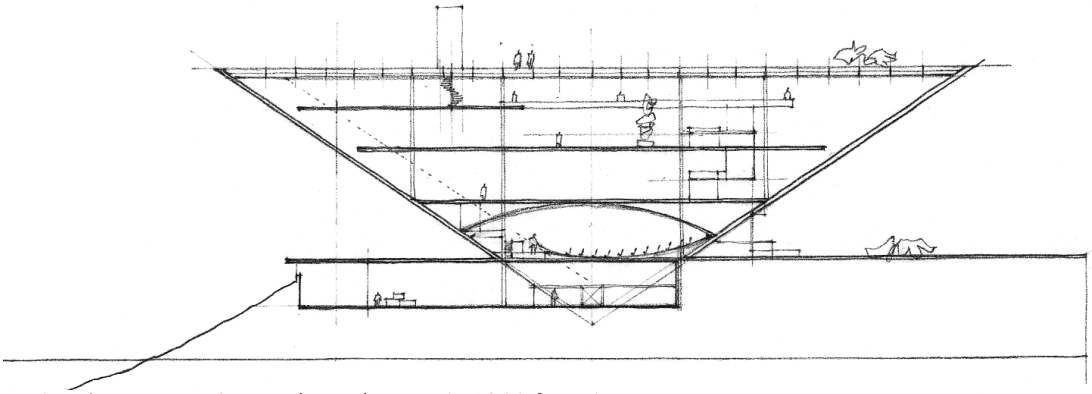
Roman Theater according to Vitruvius

TRIANGLE

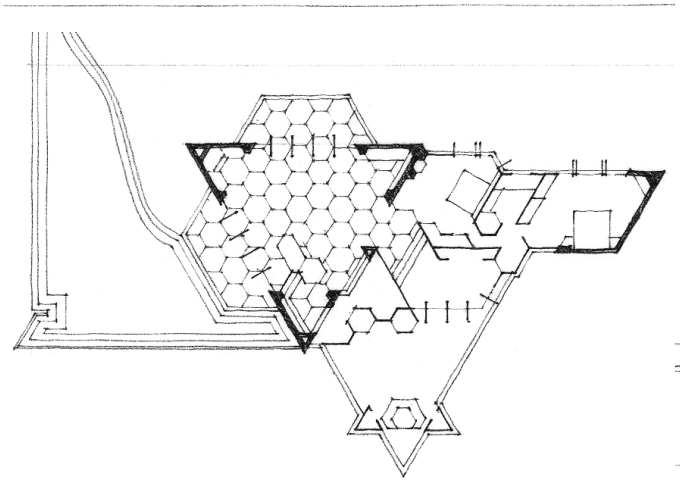




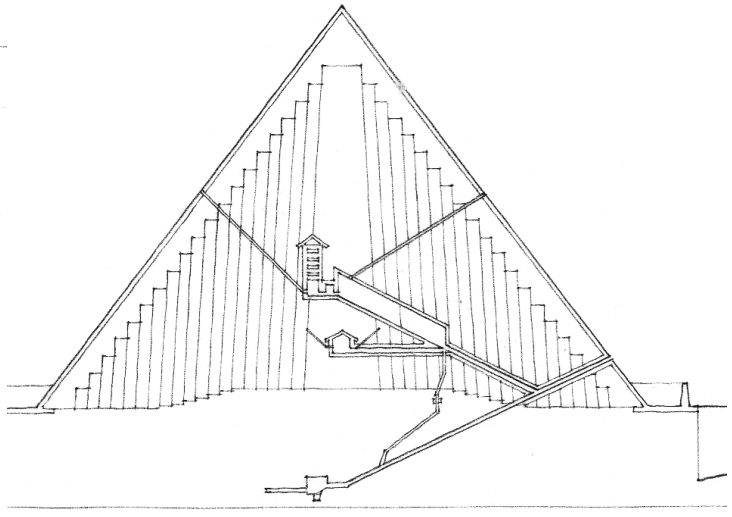
The triangle signifies stability. When resting on one of its sides, the triangle is an extremely stable figure. When tipped to stand on one of its vertices, however, it can either be balanced in a precarious state of equilibrium or be unstable and tend to fall over onto one of its sides.



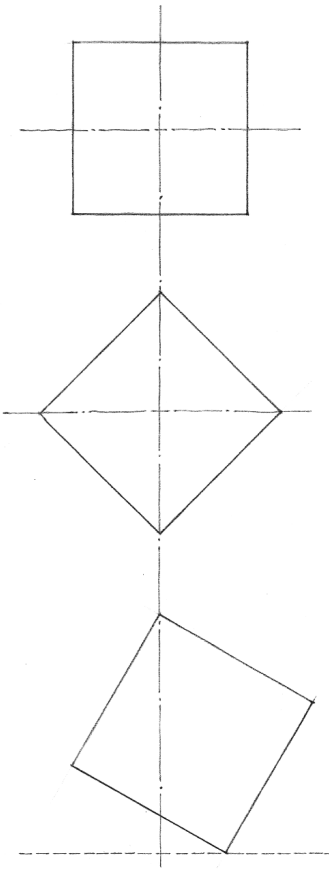
Modern Art Museum, Caracas (Project), Venezuela, 1955, Oscar Niemeyer

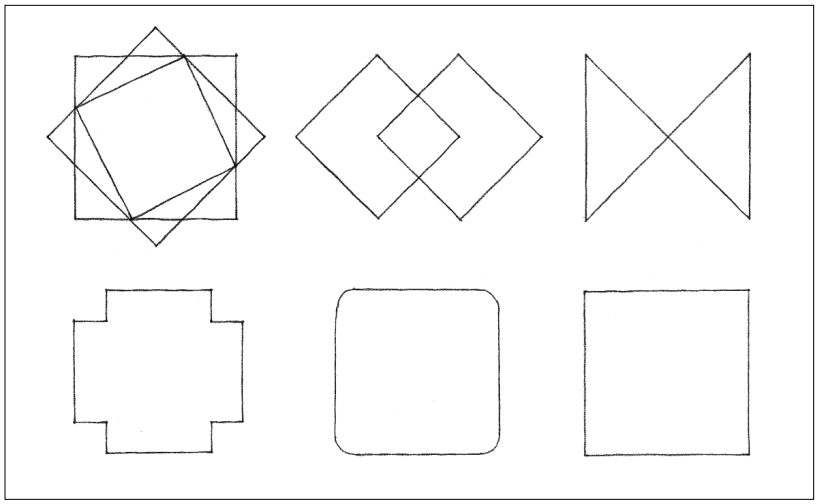


Vigo Sundt House, Madison, Wisconsin, 1942, Frank Lloyd Wright



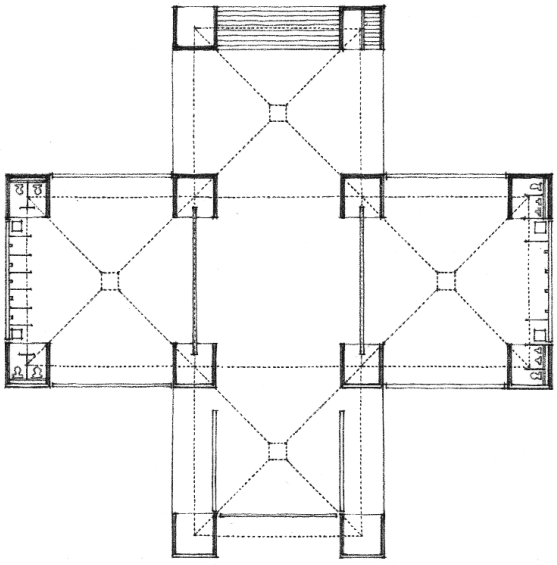
Great Pyramid of Cheops at Giza, Egypt, c. 2500 B.C.



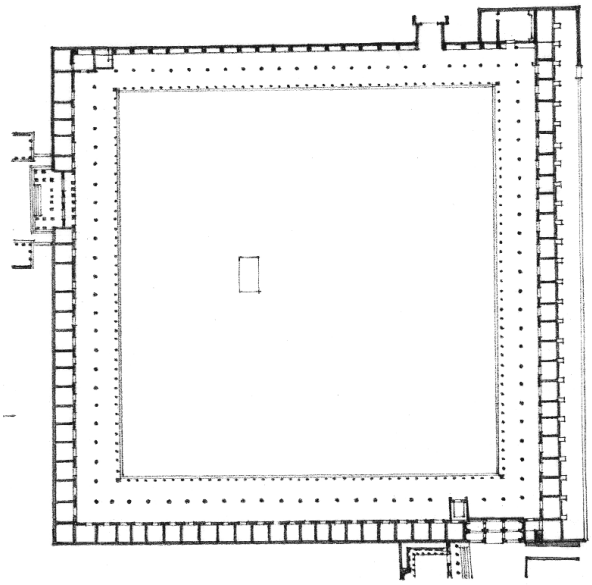


Compositions resulting from the rotation and modification of the square

The square represents the pure and the rational. It is a bilaterally symmetrical figure having two equal and perpendicular axes. All other rectangles can be considered variations of the square—deviations from the norm by the addition of height or width. Like the triangle, the square is stable when resting on one of its sides and dynamic when standing on one of its corners. When its diagonals are vertical and horizontal, however, the square exists in a balanced state of equilibrium.



Bathhouse, Jewish Community Center, Trenton, New Jersey, 1954–1959, Louis Kahn

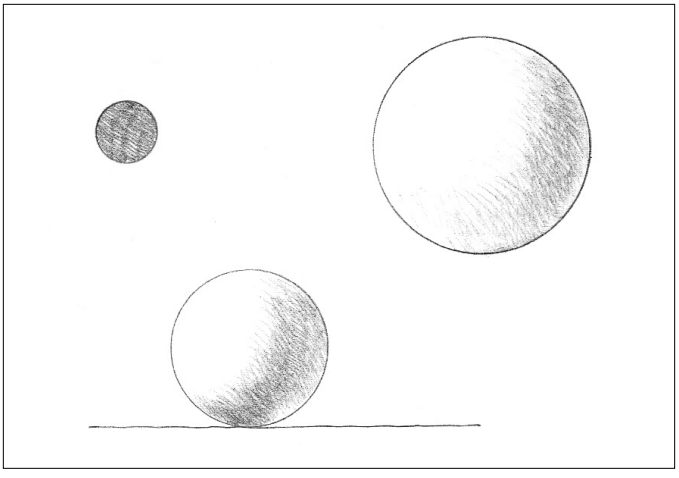


Agora of Ephesus, Asia Minor, 3rd century B. C.

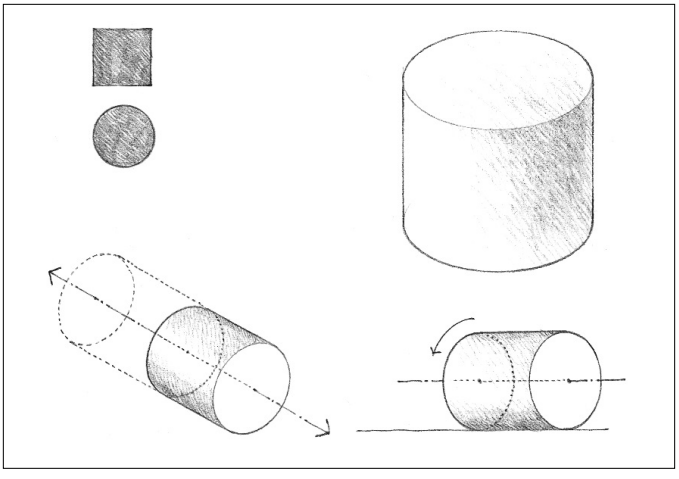
PRIMARY SOLIDS

"...cubes, cones, spheres, cylinders, or pyramids are the great primary forms that light reveals to advantage; the image of these is distinct and tangible within us and without ambiguity. It is for this reason that these are beautiful forms, the most beautiful forms." *Le Corbusier*

The primary shapes can be extended or rotated to generate volumetric forms or solids that are distinct, regular, and easily recognizable. Circles generate spheres and cylinders; triangles generate cones and pyramids; squares generate cubes. In this context, the term "solid" does not refer to firmness of substance but rather to a three-dimensional geometric body or figure.

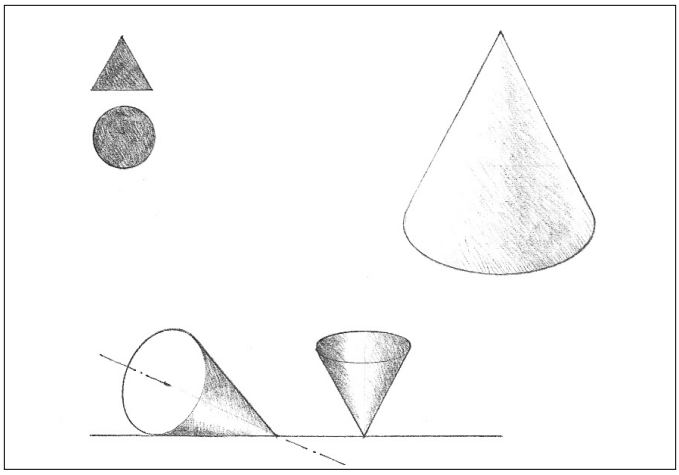


Sphere A solid generated by the revolution of a semicircle about its diameter, whose surface is at all points equidistant from the center. A sphere is a centralized and highly concentrated form. Like the circle from which it is generated, it is self-centering and normally stable in its environment. It can be inclined toward a rotary motion when placed on a sloping plane. From any viewpoint, it retains its circular shape.

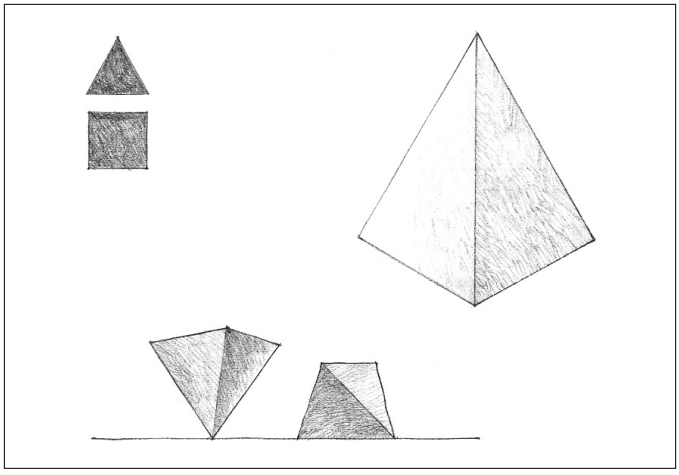


Cylinder A solid generated by the revolution of a rectangle about one of its sides. A cylinder is centralized about the axis passing through the centers of its two circular faces. Along this axis, it can be easily extended. The cylinder is stable if it rests on one of its circular faces; it becomes unstable when its central axis is inclined from the vertical.

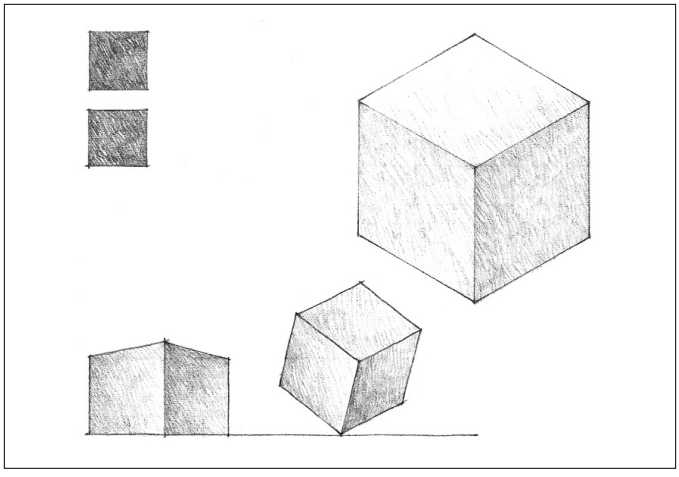
Cone A solid generated by the revolution of a right triangle about one of its sides. Like the cylinder, the cone is a highly stable form when resting on its circular base, and unstable when its vertical axis is tipped or overturned. It can also rest on its apex in a precarious state of balance.



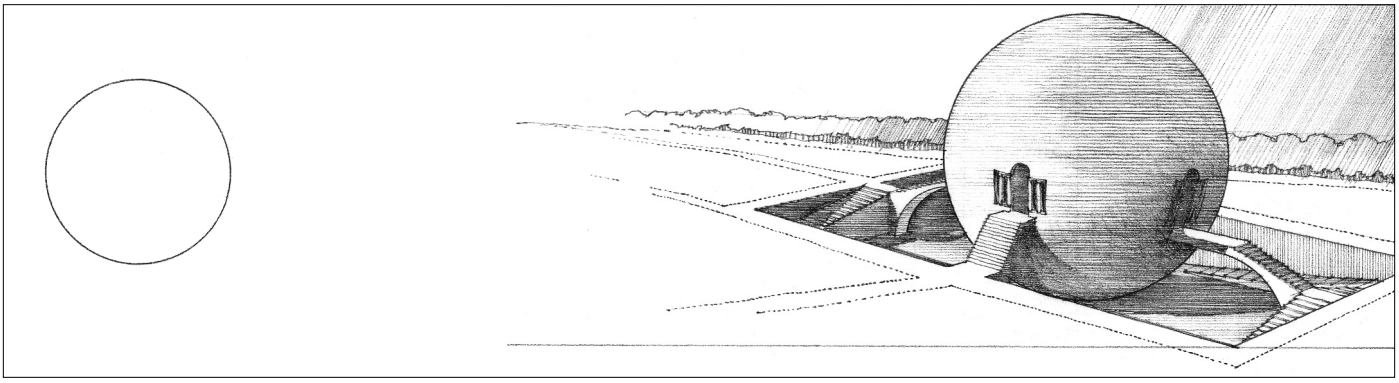
Pyramid A polyhedron having a polygonal base and triangular faces meeting at a common point or vertex. The pyramid has properties similar to those of the cone. Because all of its surfaces are flat planes, however, the pyramid can rest in a stable manner on any of its faces. While the cone is a soft form, the pyramid is relatively hard and angular.



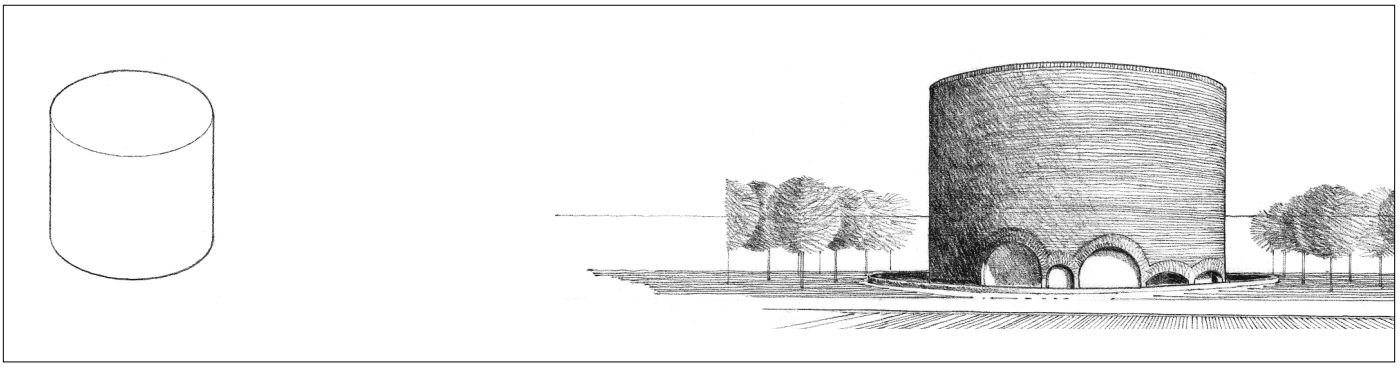
Cube A prismatic solid bounded by six equal square sides, the angle between any two adjacent faces being a right angle. Because of the equality of its dimensions, the cube is a static form that lacks apparent movement or direction. It is a stable form except when it stands on one of its edges or corners. Even though its angular profile is affected by our point of view, the cube remains a highly recognizable form.



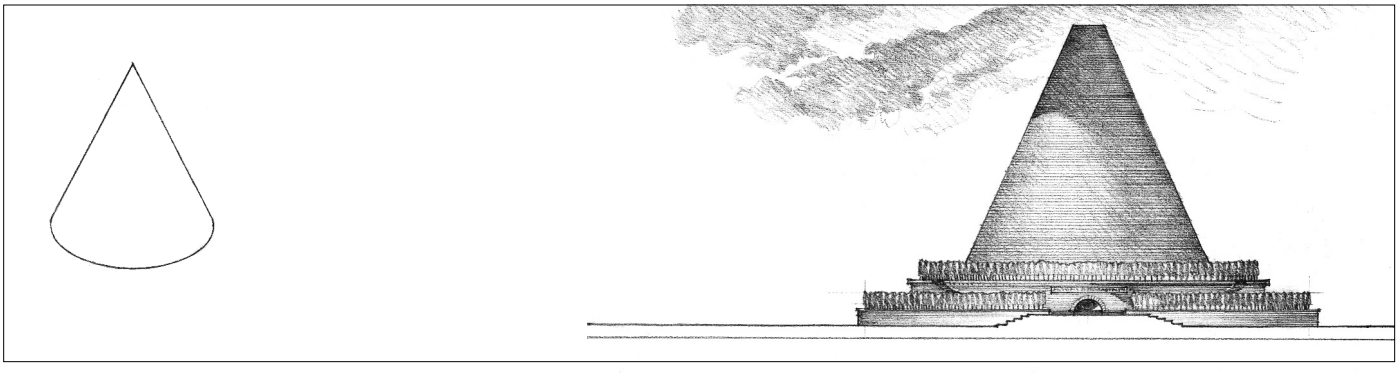
PRIMARY SOLIDS



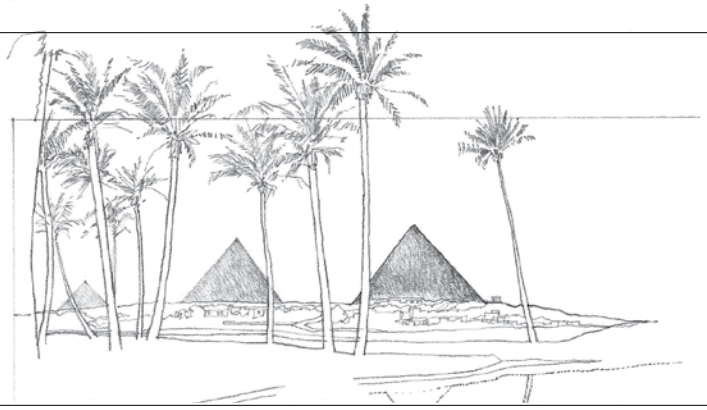
Maupertius, Project for an Agricultural Lodge, 1775, Claude-Nicolas Ledoux

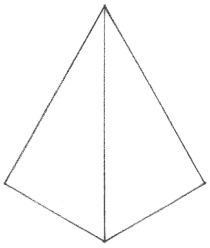


Chapel, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1955, Eero Saarinen and Associates

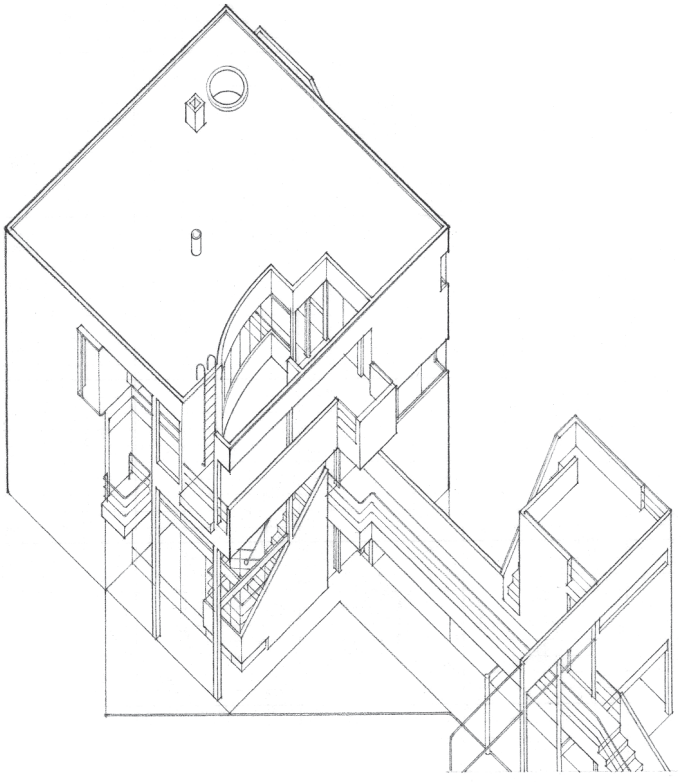


Project for a Conical Cenotaph, 1784, Étienne-Louis Boulée



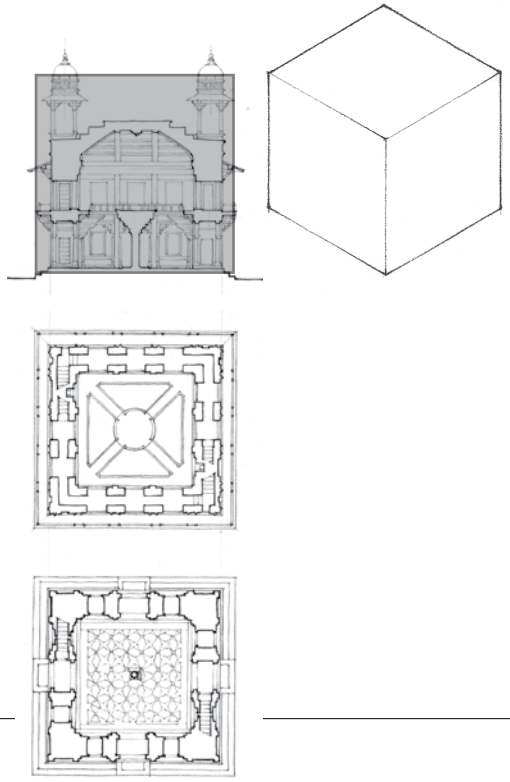


Pyramids of Cheops, Chephren, and Mykerinos at Giza, Egypt, *c.* 2500 B.C.

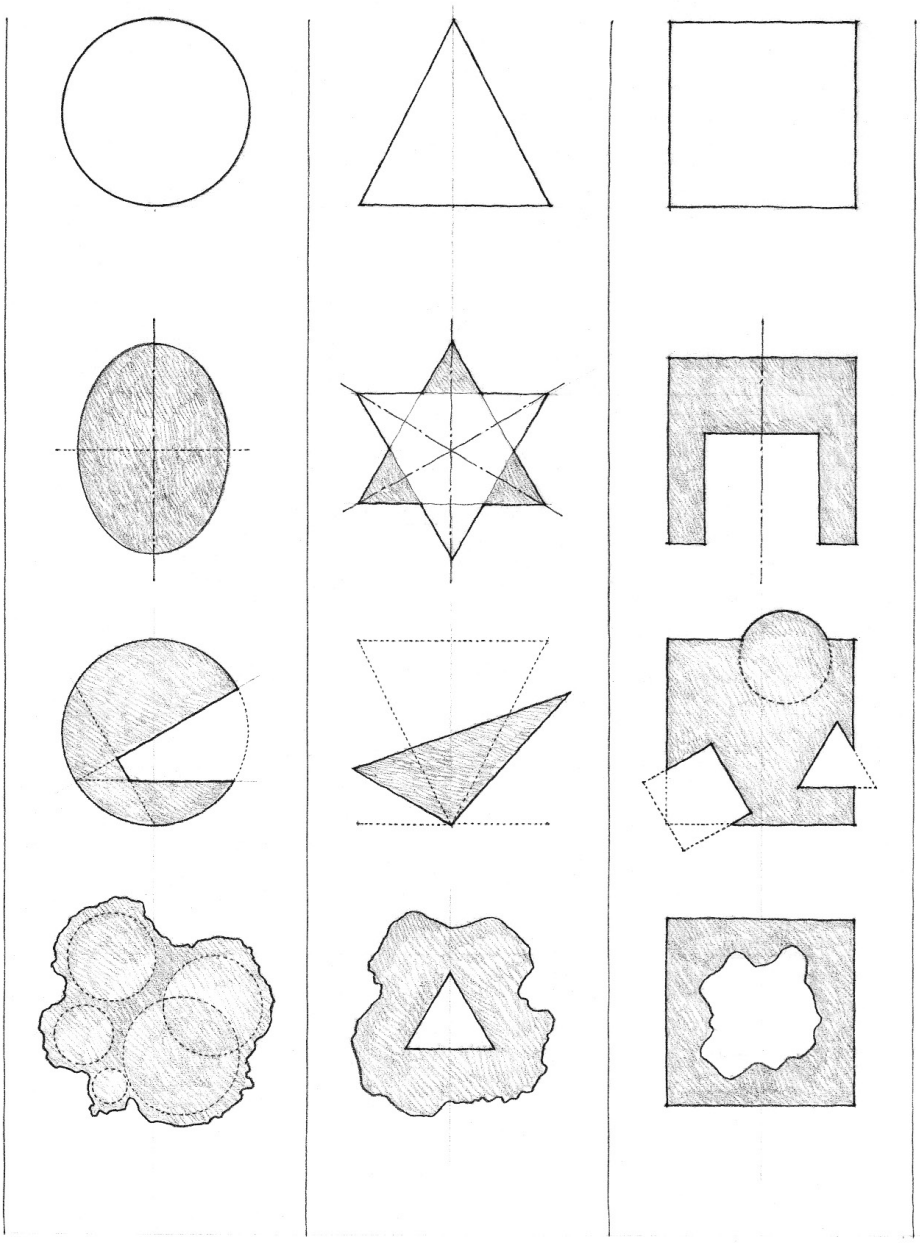


Hanselmann House, Fort Wayne, Indiana, 1967, Michael Graves

Diwan-i-Khas, Fatehpur Sikri,
Palace Complex of Akbar the Great
Mogul Emperor of India, 1569–1574



REGULAR & IRREGULAR FORMS

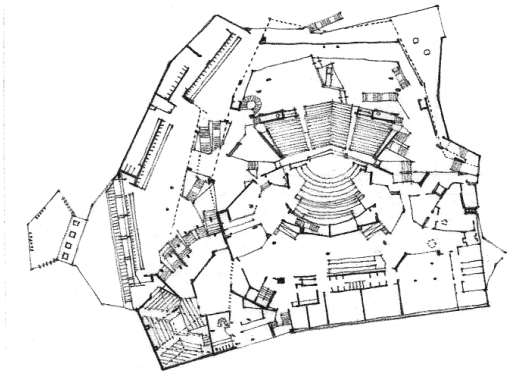


Regular forms refer to those whose parts are related to one another in a consistent and orderly manner. They are generally stable in nature and symmetrical about one or more axes. The sphere, cylinder, cone, cube, and pyramid are prime examples of regular forms.

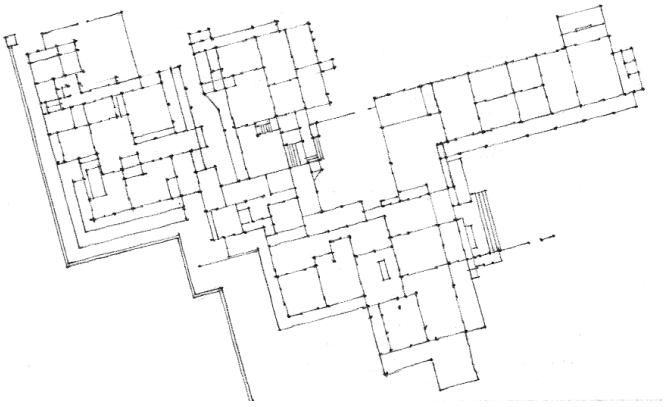
Forms can retain their regularity even when transformed dimensionally or by the addition or subtraction of elements. From our experiences with similar forms, we can construct a mental model of the original whole even when a fragment is missing or another part is added.

Irregular forms are those whose parts are dissimilar in nature and related to one another in an inconsistent manner. They are generally asymmetrical and more dynamic than regular forms. They can be regular forms from which irregular elements have been subtracted or result from an irregular composition of regular forms.

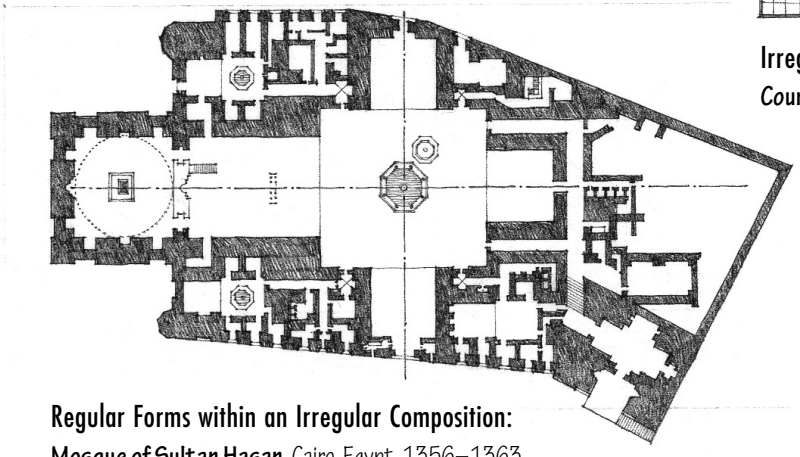
Since we deal with both solid masses and spatial voids in architecture, regular forms can be contained within irregular forms. In a similar manner, irregular forms can be enclosed by regular forms.



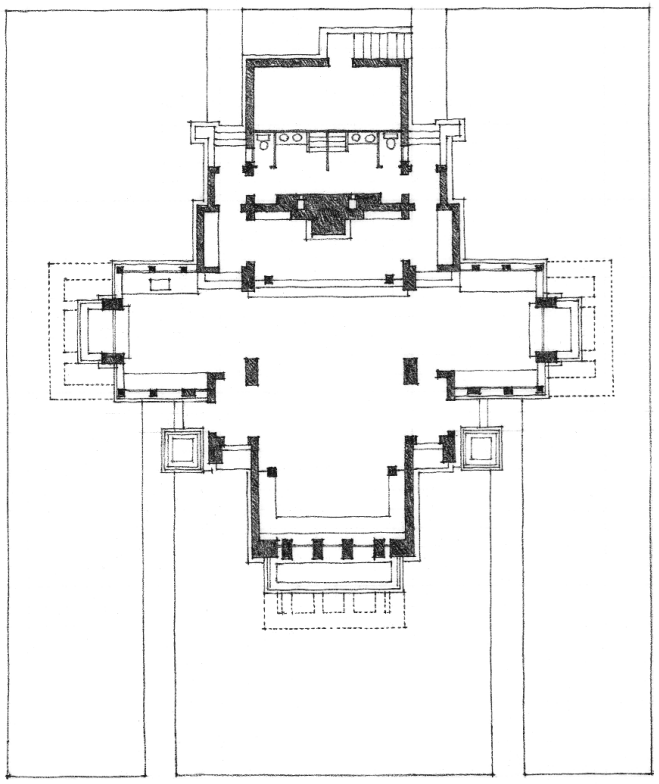
Irregular Forms:
Philharmonic Hall, Berlin, 1956–1963, Hans Scharoun



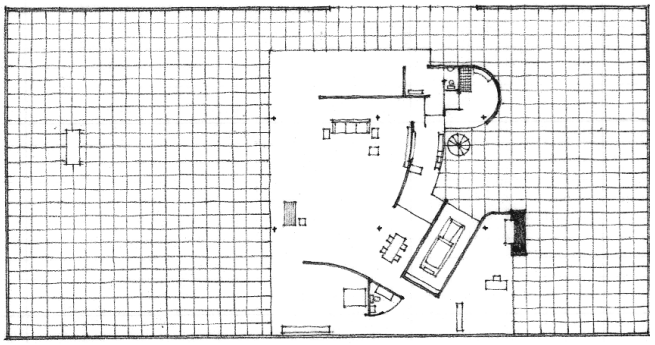
An Irregular Composition of Regular Forms:
Katsura Imperial Villa, Kyoto, Japan, 17th century



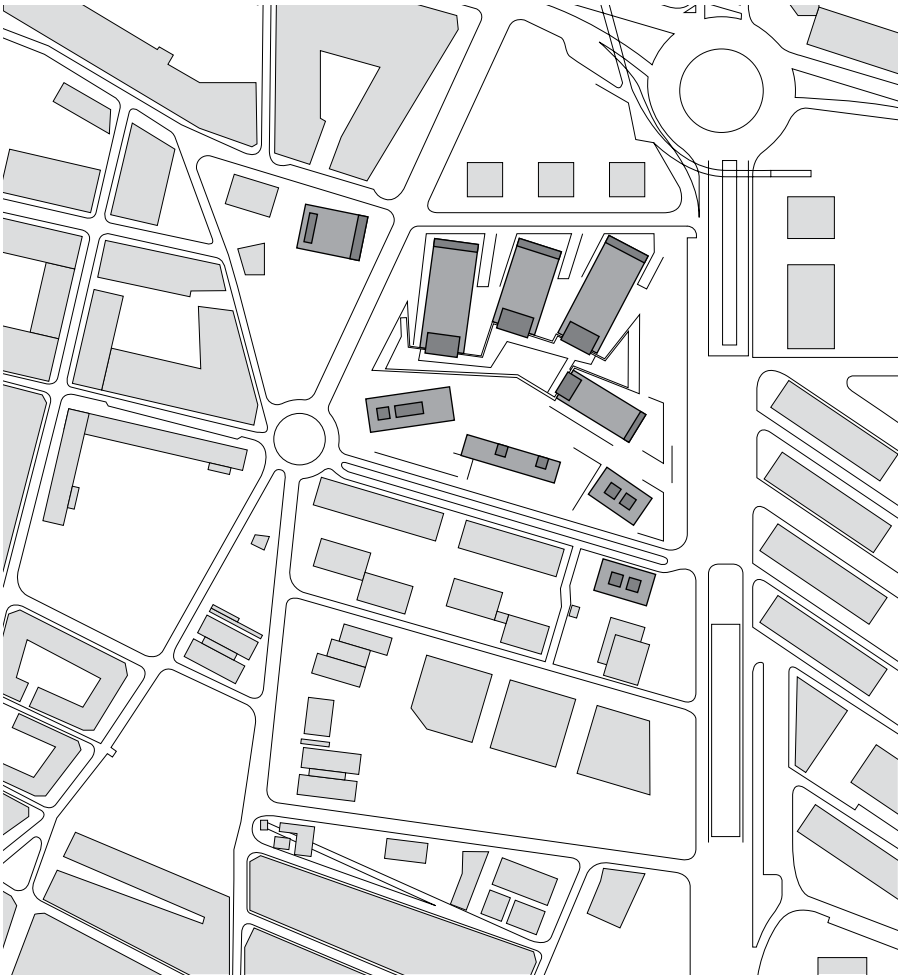
Regular Forms within an Irregular Composition:
Mosque of Sultan Hasan, Cairo, Egypt, 1356–1363



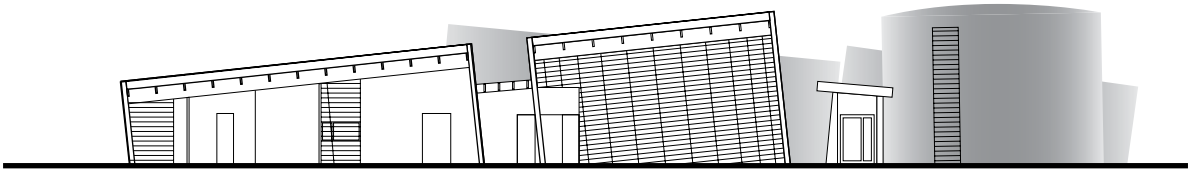
A Regular Composition of Regular Forms:
Coonley Playhouse, Riverside, Illinois, 1912, Frank Lloyd Wright



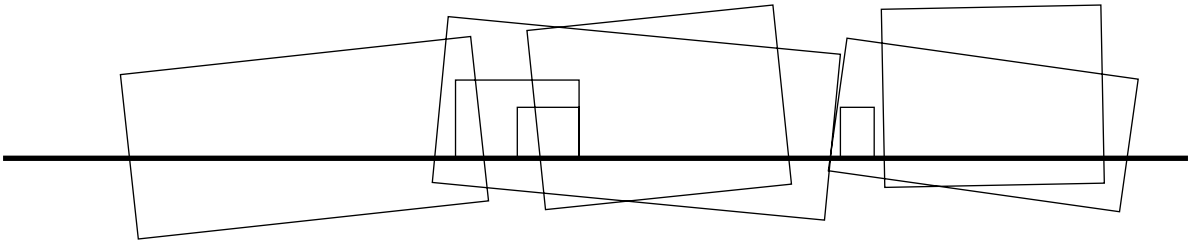
Irregular Forms within a Regular Field:
Courtyard House Project, 1934, Mies van de Rohe

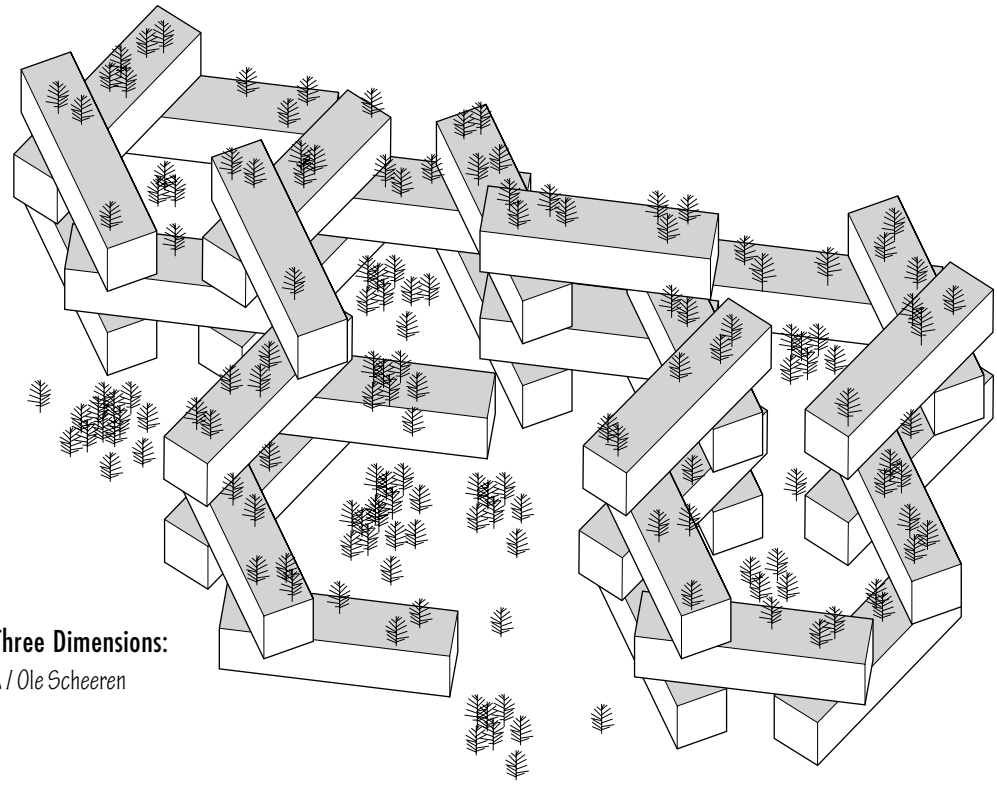


An Irregular Array of Regular Forms in the Horizontal Dimension:
City of Justice, Barcelona, Spain, 2010, David Chipperfield Architects, b720 Arquitectos

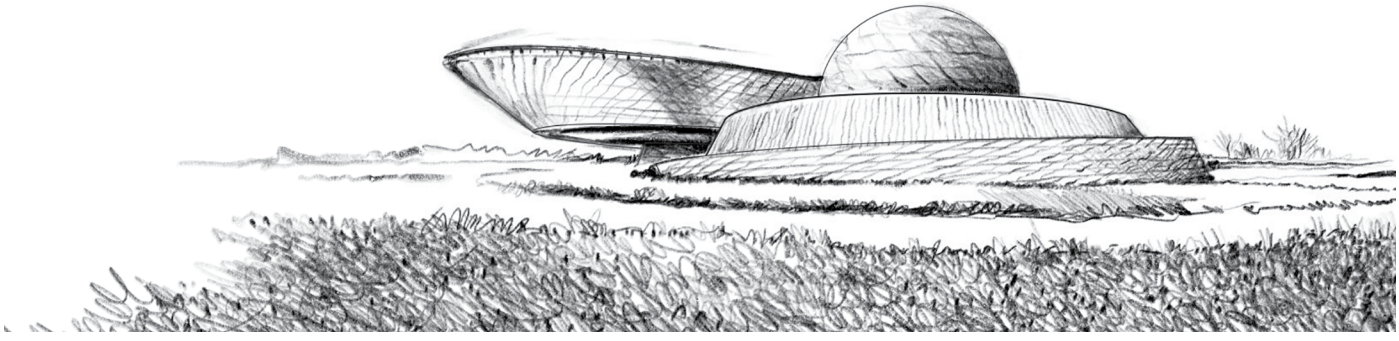


An Irregular Array of Regular Forms in the Vertical Dimension: **Poteries du Don**, Le Fel, France, 2008, Lacombe–De Florinier

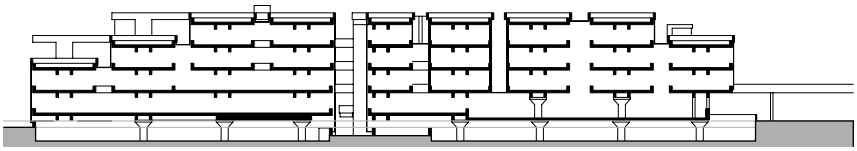




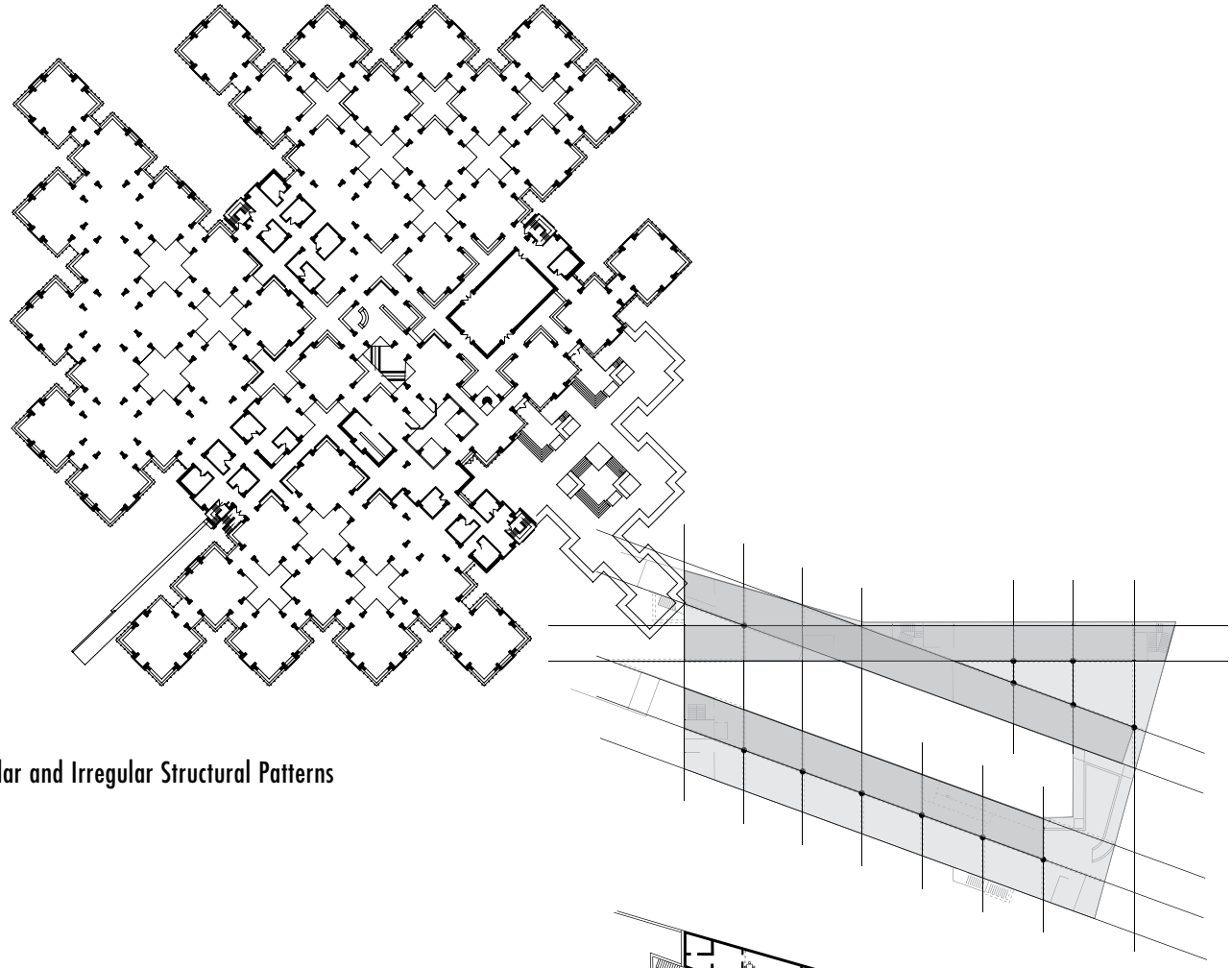
An Irregular Array of Regular Forms in Three Dimensions:
The Interlace, Singapore, 2007–2013, OMA / Ole Scheeren



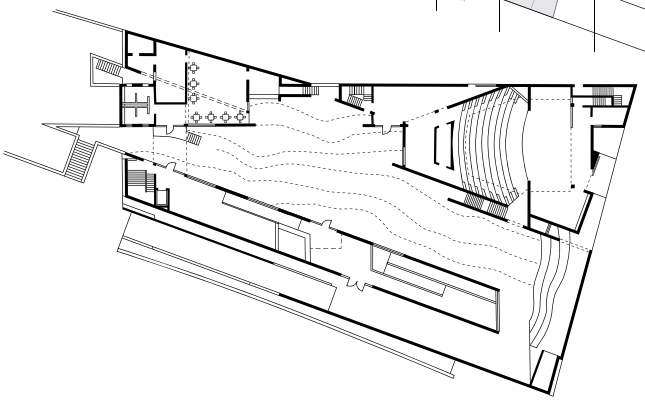
An Irregular Array of Both Regular and Irregular Forms in Three Dimensions:
Shanghai Astronomy Museum, Shanghai, China, 2021, Ennead Architects



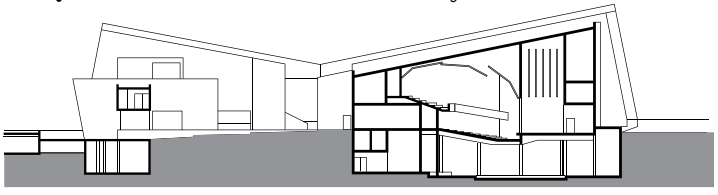
Centraal Beheer Insurance Offices, Apeldoorn, Netherlands, 1967–1972, Herman Hertzberger



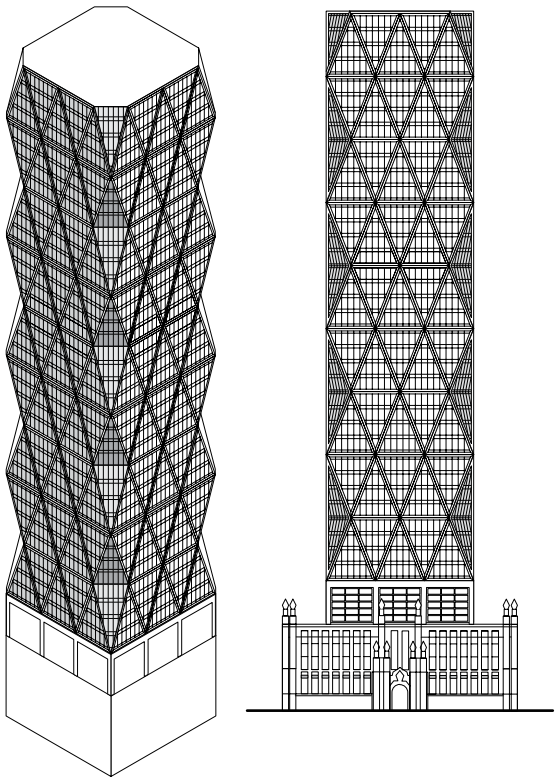
Regular and Irregular Structural Patterns

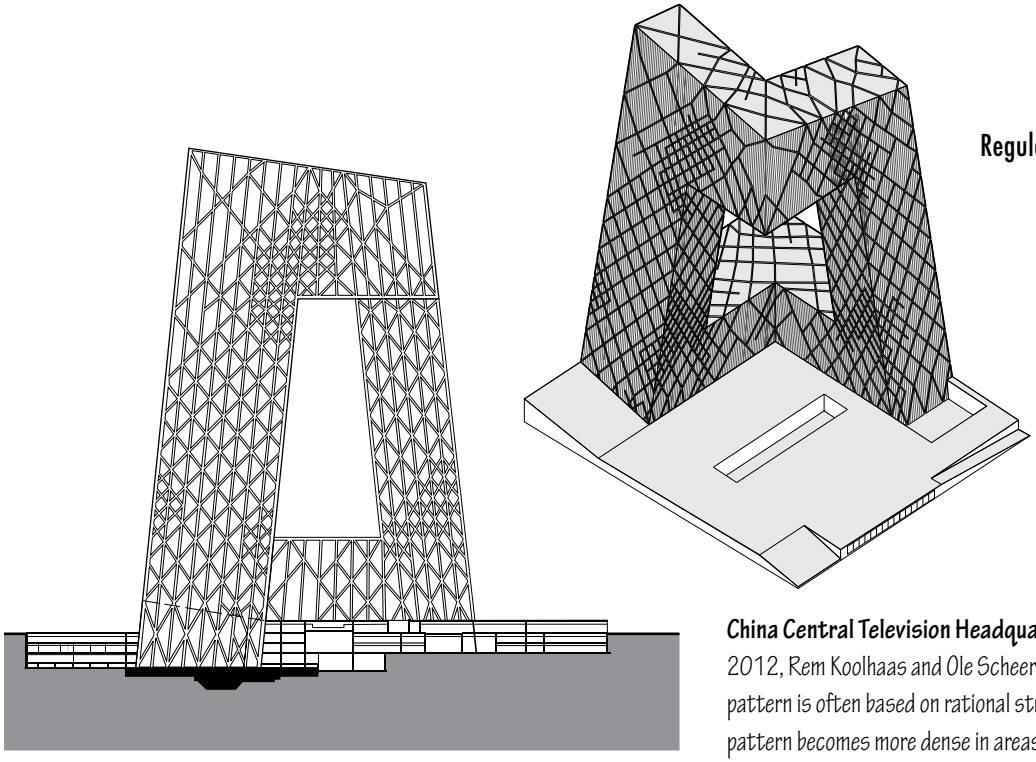


Palmach Museum of History, Tel Aviv, Israel, 1998, Zvi Hecker and Rafi Segal



Hearst Tower, New York City, Completed 2006, Norman Foster. The 46-story structure rises nearly 600 feet above its landmark six-story base, the International Magazine Building, originally built by William Randolph Hearst in 1928. Because the triangulated three-dimensional form of the steel diagrid structure is capable of both supporting gravity loads and resisting lateral wind forces, there is no need for exterior vertical columns. The diagrid structure reportedly used 20% less steel than a conventionally framed high-rise of similar size.



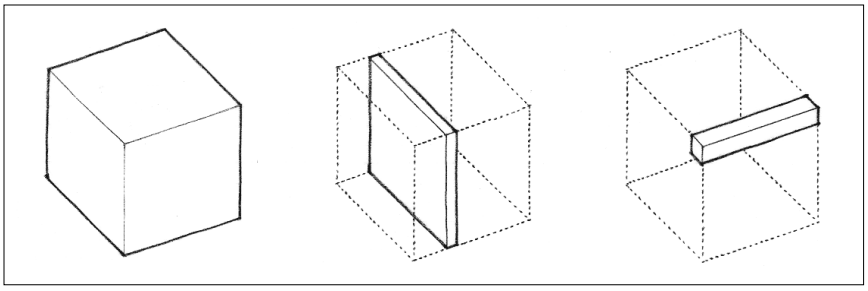


Regular and Irregular Structural Patterns

China Central Television Headquarters (CCTV), Beijing, China, 2004–2012, Rem Koolhaas and Ole Scheeren/OMA. What may appear to be a random pattern is often based on rational structural principles. Note how the diagrid pattern becomes more dense in areas where moment stresses are higher.

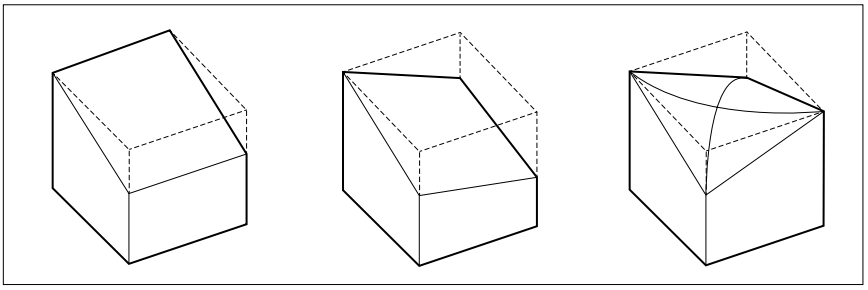
TRANSFORMATION OF FORM

All other forms can be understood to be transformations of the primary solids, variations which are generated by the manipulation of one or more dimensions, by the altering of geometric relationships, or by the addition or subtraction of elements.



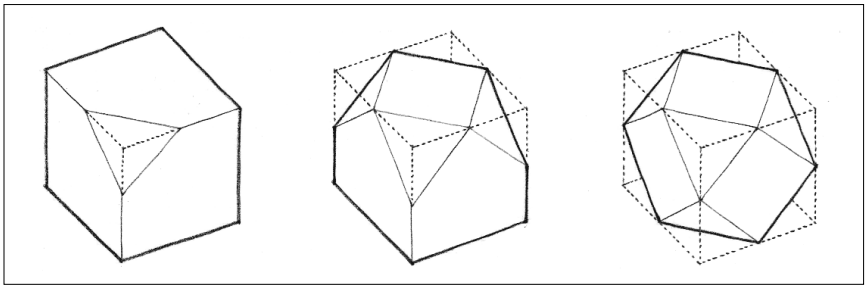
Dimensional Transformation

A form can be transformed by altering one or more of its dimensions and still retain its identity as a member of a family of forms. A cube, for example, can be transformed into similar prismatic forms through discrete changes in height, width, or length. It can be compressed into a planar form or be stretched out into a linear one.



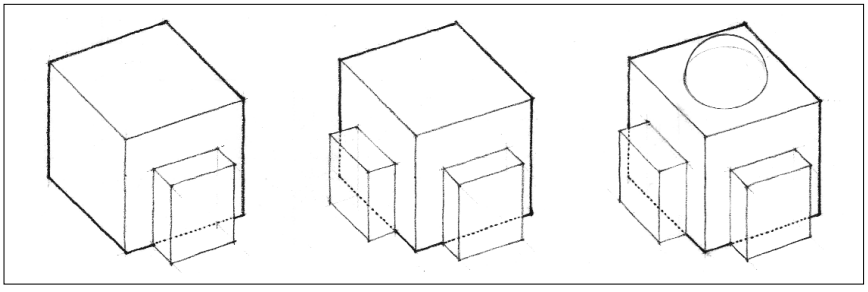
Geometric Transformation

A form can be transformed by altering the shapes and geometric relationships of its enclosing planes. A square prism, for example, can be transformed by shifting the relationship between its two base faces; a plane can be transformed into a saddle surface by generating an upward curvature in one direction and a downward curvature in the perpendicular direction.



Subtractive Transformation

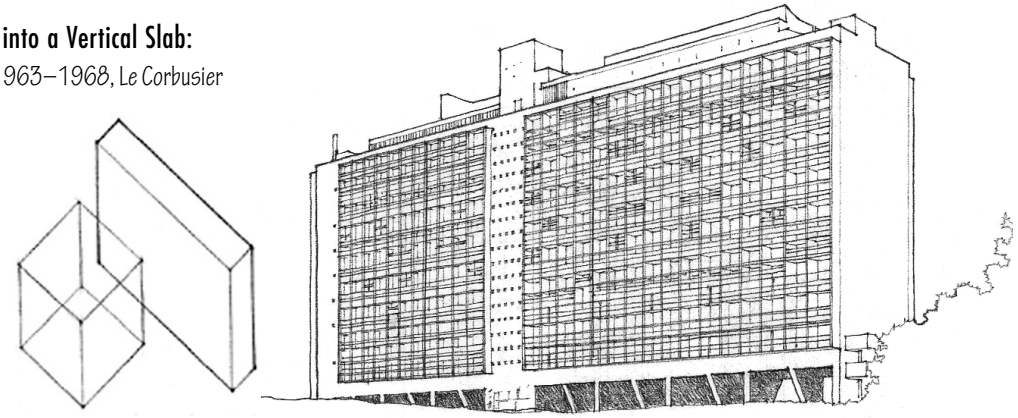
A form can be transformed by subtracting a portion of its volume. Depending on the extent of the subtractive process, the form can retain its initial identity or be transformed into a form of another family. For example, a cube can retain its identity as a cube even though a portion of it is removed, or be transformed into a series of regular polyhedrons that begin to approximate a sphere.

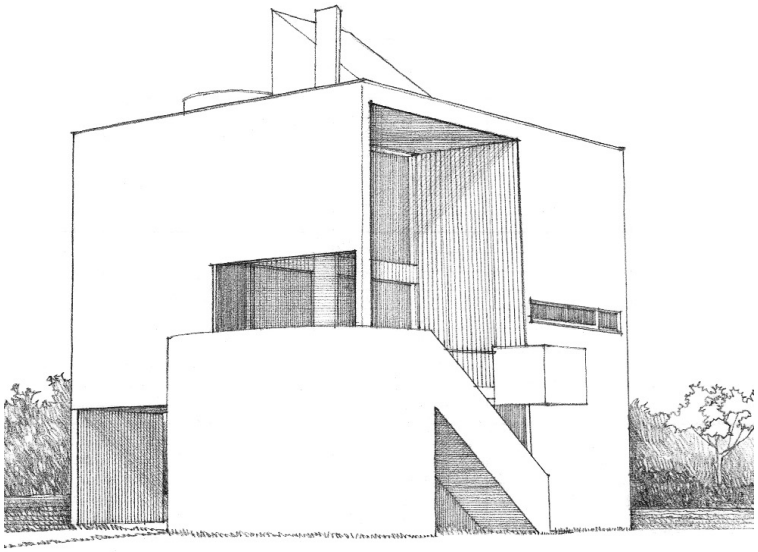


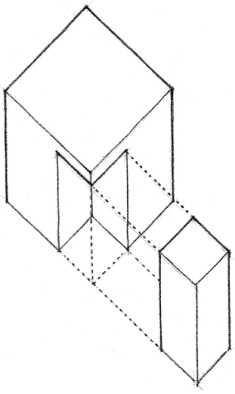
Additive Transformation

A form can be transformed by the addition of elements to its volume. The nature of the additive process and the number and relative sizes of the elements being attached determine whether the identity of the initial form is altered or retained.

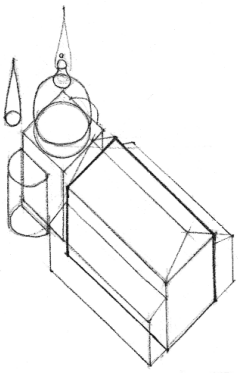
Dimensional Transformation of a Cube into a Vertical Slab:
Unité d'Habitation, *Firminy-Vert, France, 1963–1968, Le Corbusier*





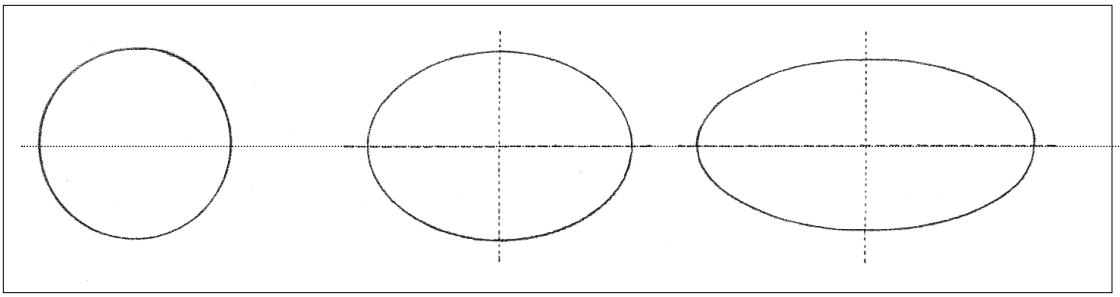


Subtractive Transformation Creating Volumes of Space:
Gwathmey Residence, *Amagansett, New York, 1967,*
Charles Gwathmey/Gwathmey Siegel

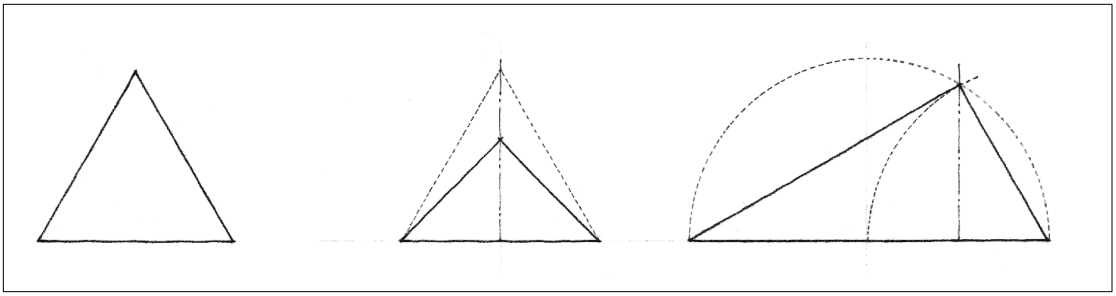


Additive Transformation of a Parent Form by the Attachment of Subordinate Parts:
Il Redentore, *Venice, 1577–1592, Andrea Palladio*

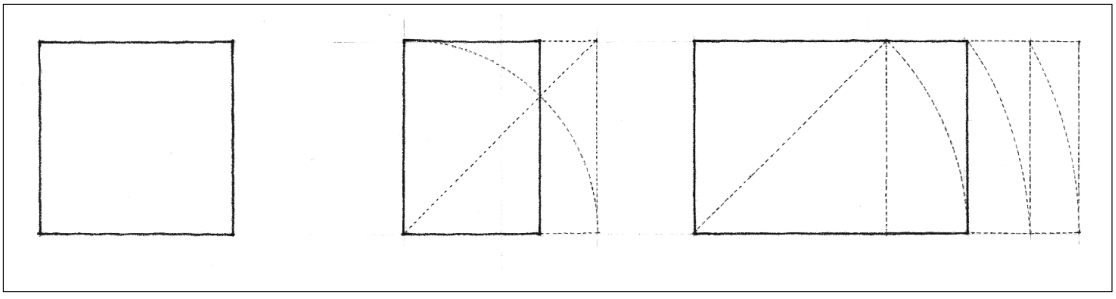
DIMENSIONAL TRANSFORMATION



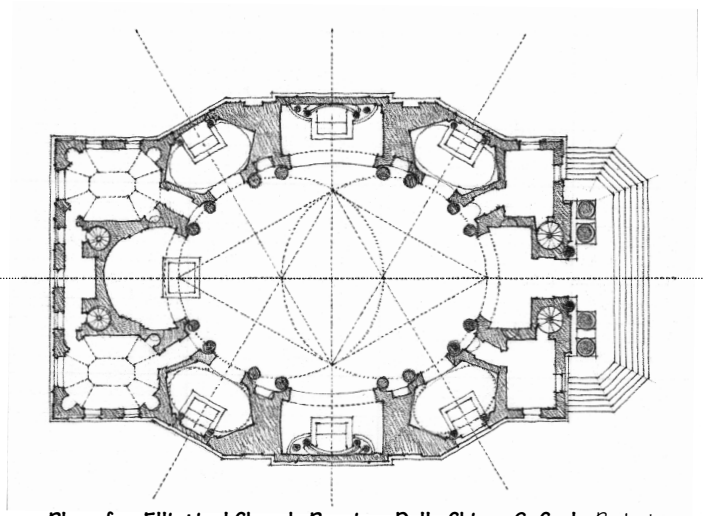
A sphere can be transformed into any number of ovoid or ellipsoidal forms by elongating it along an axis.



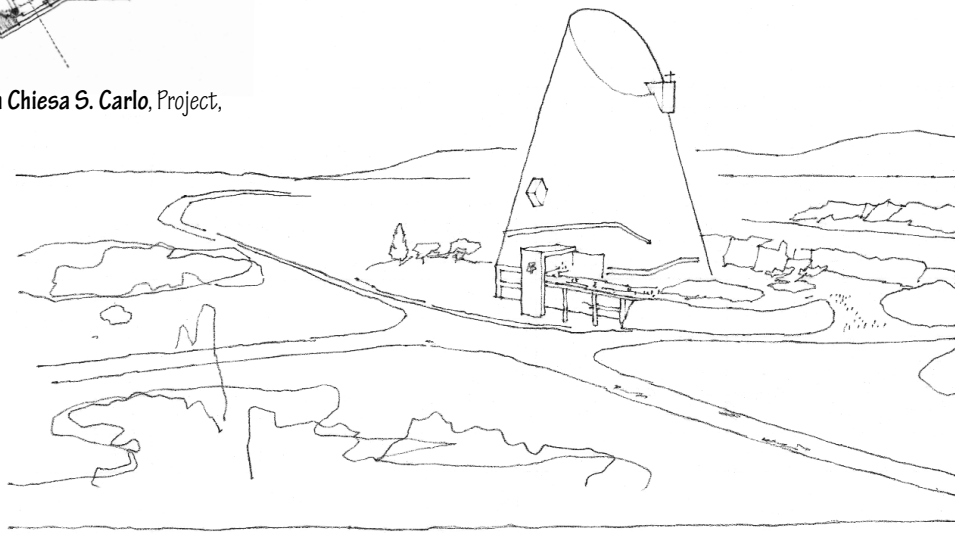
A pyramid can be transformed by altering the dimensions of the base, modifying the height of the apex, or tilting the normally vertical axis.



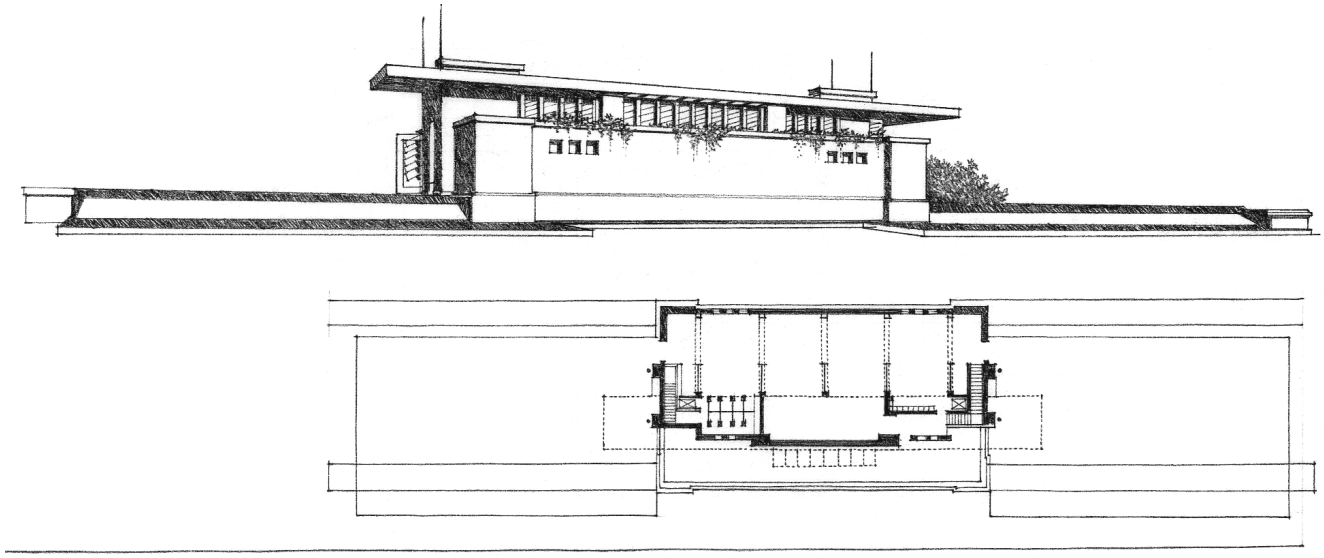
A cube can be transformed into similar prismatic forms by shortening or elongating its height, width, or depth.



Plan of an Elliptical Church, Pensiero Della Chiesa S. Carlo, Project, 17th century, Francesco Borromini

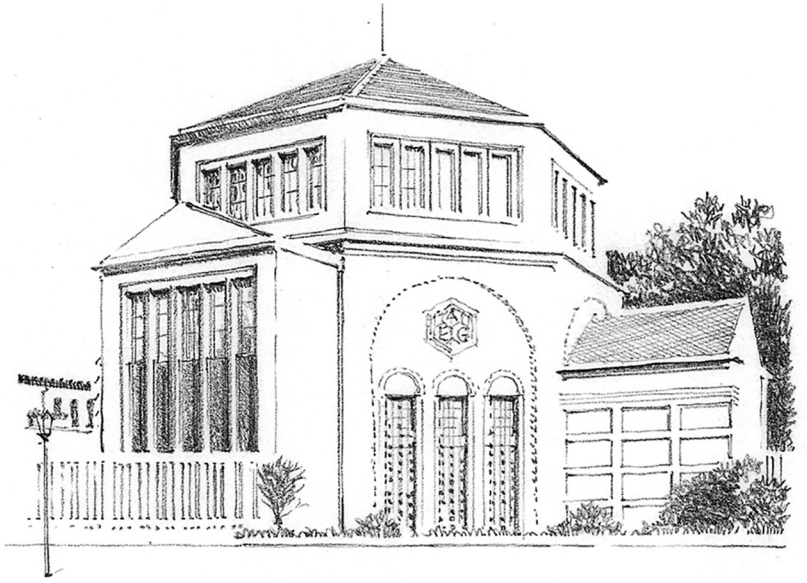


St. Pierre, Firminy-Vert, France, 1965, Le Corbusier



Project for Yahara Boat Club, Madison, Wisconsin, 1902, Frank Lloyd Wright

DIMENSIONAL TRANSFORMATION

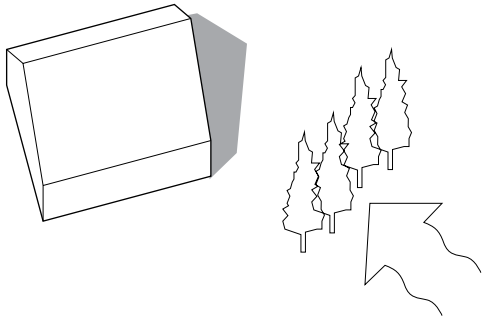


AEG Pavilion, German Shipbuilding Exhibition of 1908, Berlin, Peter Behrens

While the size and proportions of a site, functional program requirements, and zoning constraints all influence the shape and proportions of a building, there are environmental and climatic factors to consider as well.

The location, form, and orientation of a building and its spaces should take advantage of the thermal, hygienic, and psychological benefits of sunlight. Solar radiation, however, may not always be beneficial, depending on the latitude and climate of the site. In planning the design of a building, the objective should be to maintain a balance between underheated periods when solar radiation is beneficial and overheated periods when radiation should be avoided.

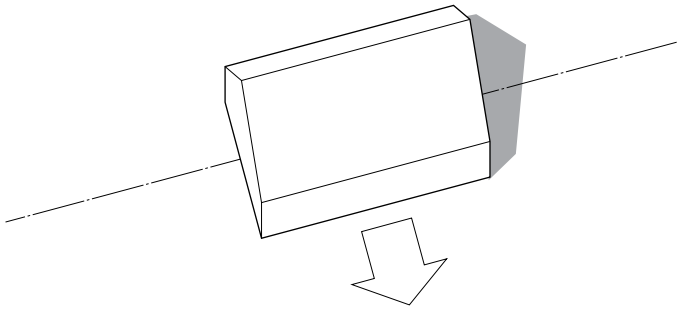
The following are recommended forms and orientations for isolated buildings in different climatic regions. The information presented should be considered along with other contextual and programmatic requirements.



Cool Regions

Minimizing the surface area of a building reduces exposure to low temperatures.

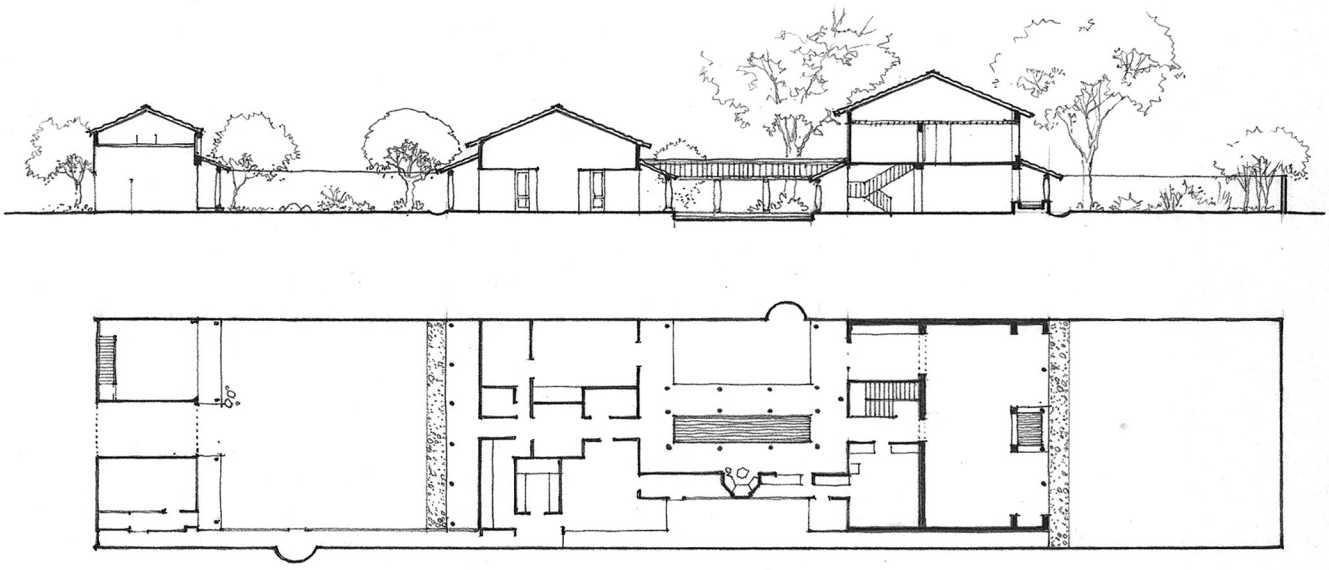
- Closed, compact forms are preferable.
- Maximize absorption of solar radiation.
- Reduce radiant, conductive, and evaporative heat loss.
- Provide wind protection.



Temperate Regions

Elongating the form of a building along the east-west axis maximizes south-facing walls.

- Minimize east and west exposures, which are generally warmer in summer and cooler in winter than southern exposures.
- Balance solar heat gain with shade protection on a seasonal basis.
- Encourage air movement in hot weather; protect against wind in cold weather.

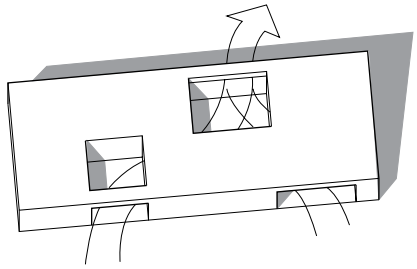


House for Dr. Bartholomeusz, Colombo, Sri Lanka, 1963, Geoffrey Bawa. Courtyards, loggias, and verandas create a pleasant and comfortable environment without the need for air-conditioning.

Hot-Humid Regions

Building form elongated along the east-west axis minimizes east and west exposures.

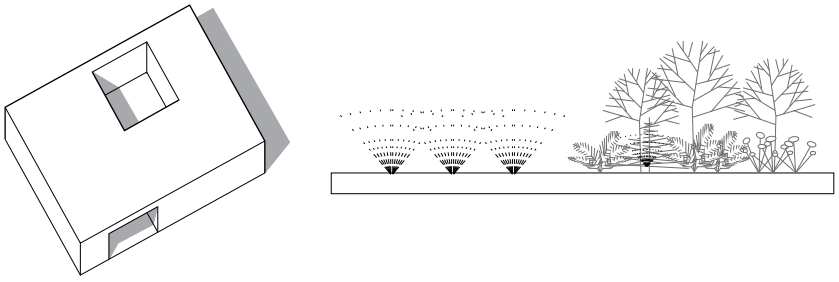
- Reduce solar heat gain.
- Utilize wind to promote cooling by evaporation.
- Provide solar shading for windows and outdoor spaces.



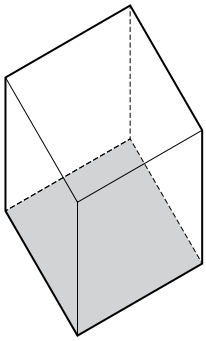
Hot-Arid Regions

Building forms should enclose courtyard spaces.

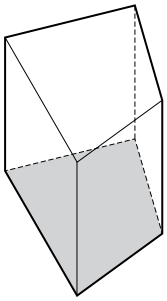
- Reduce solar and conductive heat gain.
- Promote cooling by evaporation using water features and plantings.
- Provide solar shading for windows and outdoor spaces.



By definition, a prism is a polyhedron—a three-dimensional solid formed by plane faces—having two polygonal base faces lying in parallel planes and the other lateral faces being rectangles or parallelograms. The base faces may be triangles, squares, rectangles, or any n-sided polygon, such as a pentagon or hexagon.

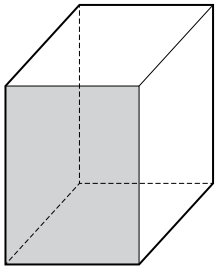


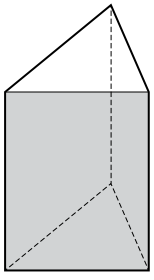
Regular Prism



Irregular Prism

- Regular prisms have regular polygonal base faces while irregular prisms have irregular polygonal bases.

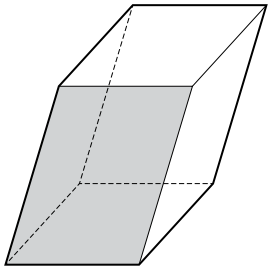


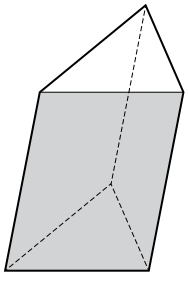


Right Prisms

- Prisms can also be categorized by the angular relationship between their base and lateral faces. Right prisms have rectangular lateral faces and joining edges perpendicular to their base faces.

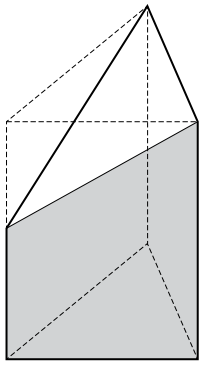
- Oblique prisms have lateral faces that are not perpendicular to their base faces, resulting in their shapes being parallelograms.





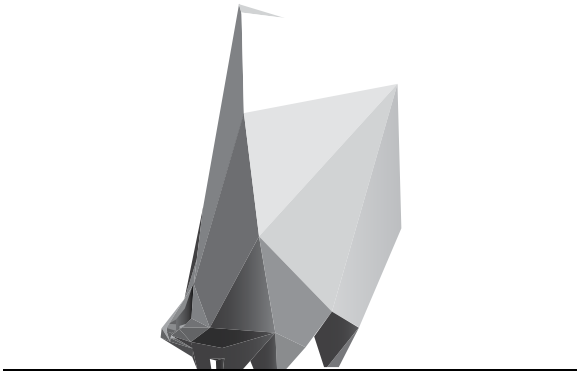
Oblique Prisms

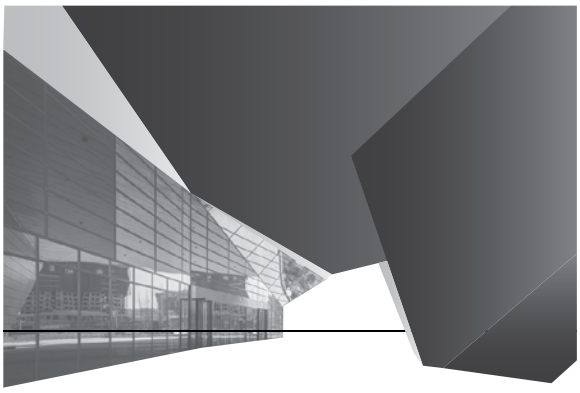
- Prismatic forms can be distorted, warped, or otherwise transformed to produce a wide range of dynamic shapes. One example is the truncated prism that has nonparallel top and bottom faces.



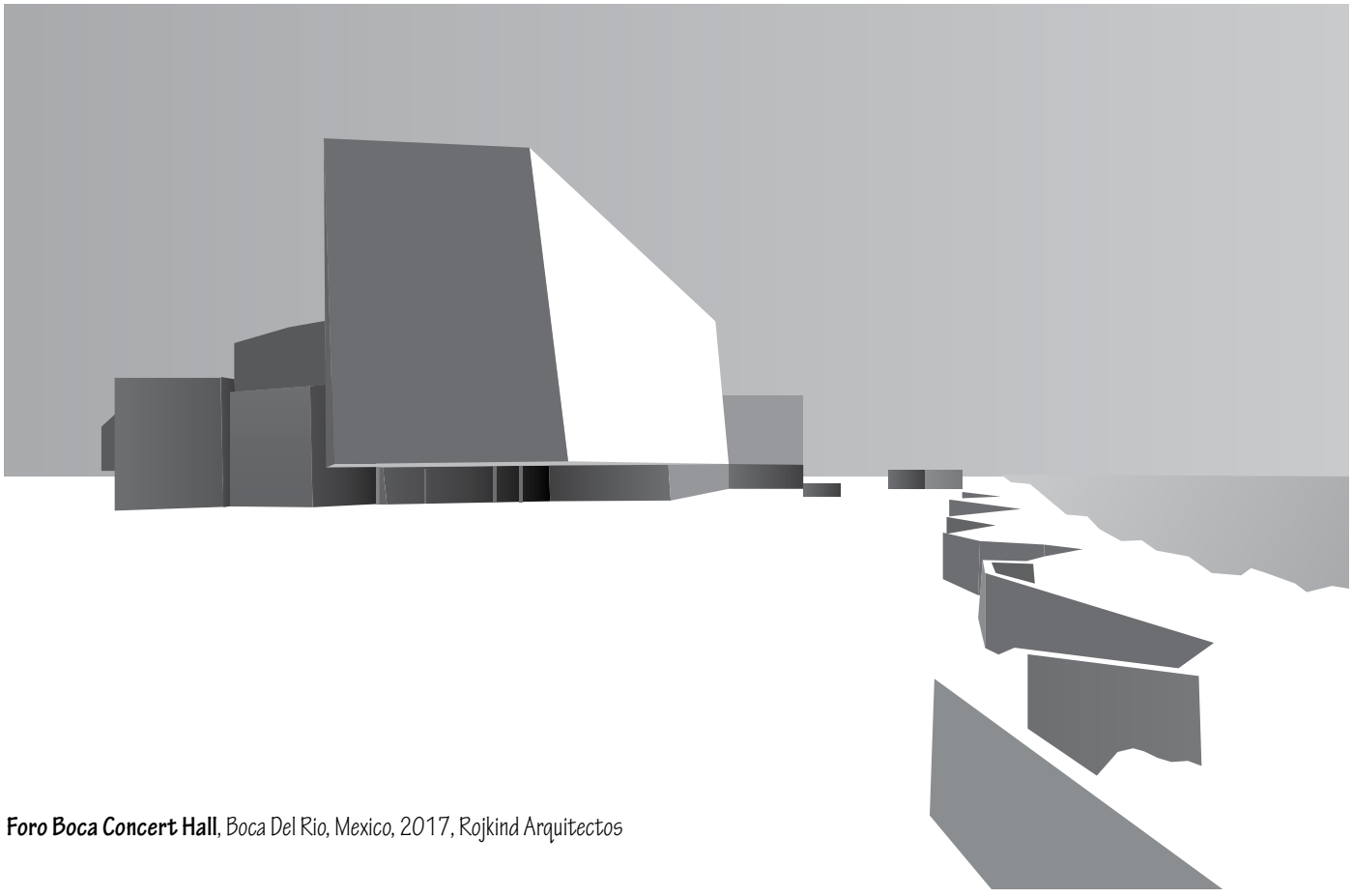
Truncated Triangular Prism

Visually, prismatic forms are characterized by planes intersecting at sharp angles, resulting in shapes and structures that exhibit crispness and precision. These geometric shapes will vary according to our point of view and the manner of illumination.

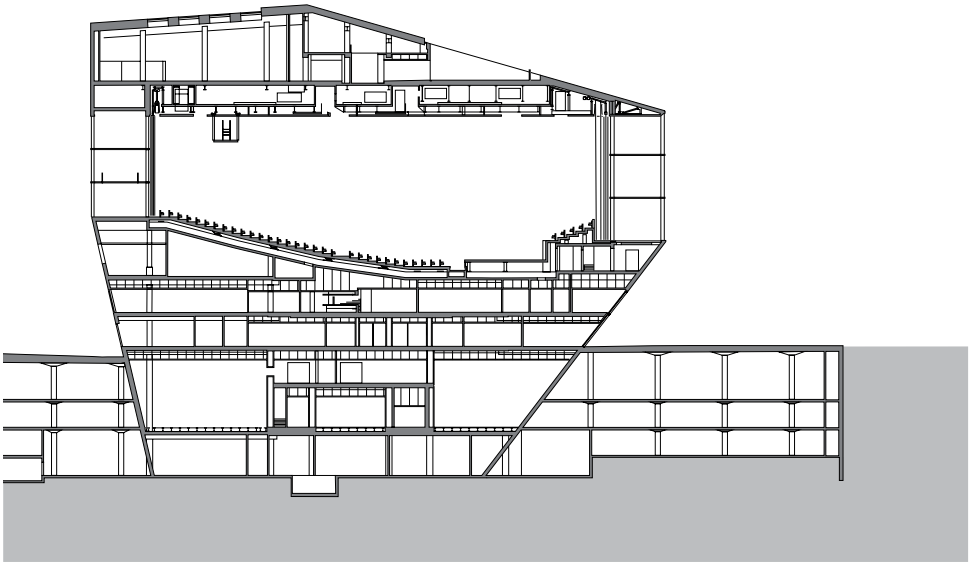




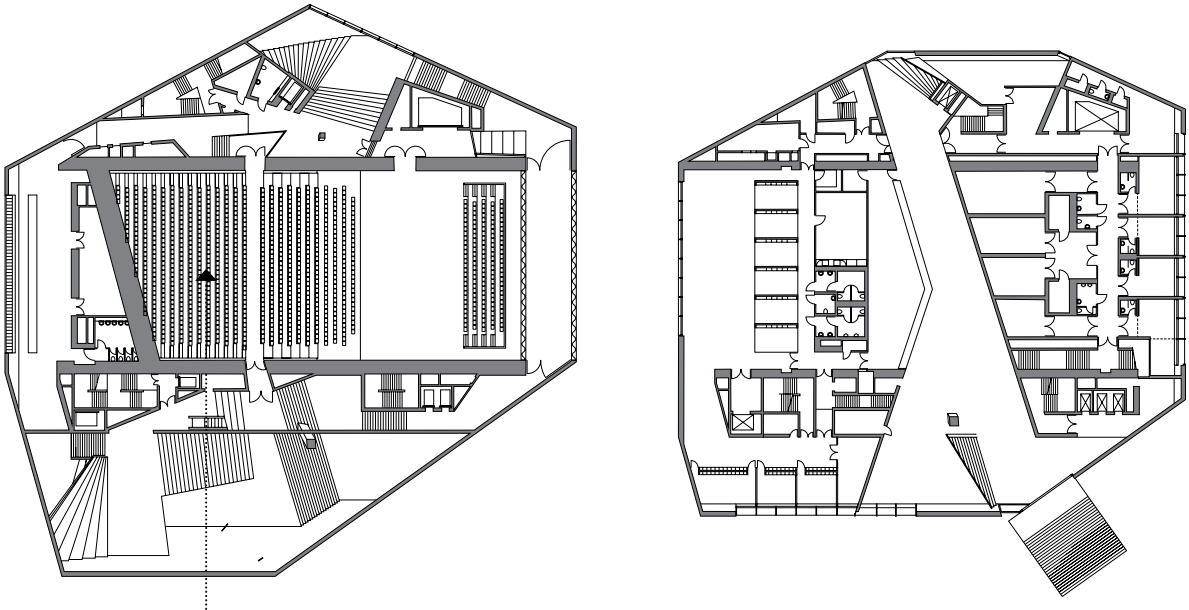
Wenling Museum, Wenling, China, 2018, CCTN Architectural Design Company



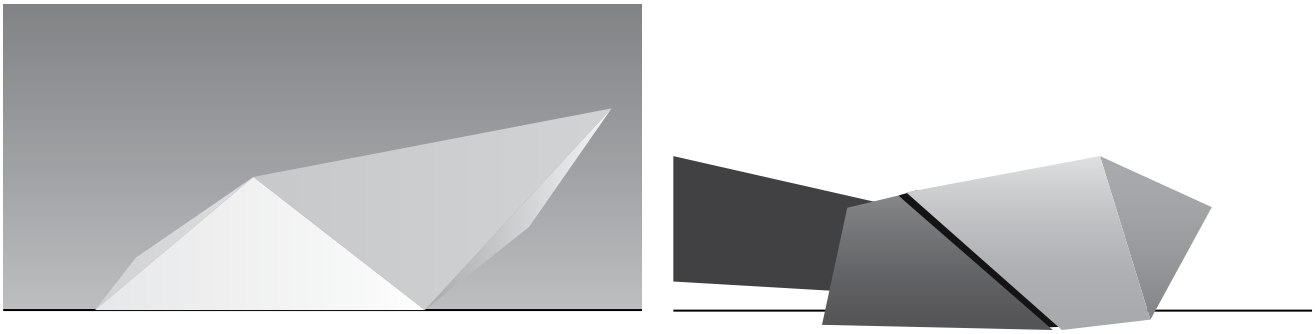
Foro Boca Concert Hall, Boca Del Rio, Mexico, 2017, Rojkind Arquitectos



***Casa de* Música,** *Porto, Portugal, 2005, Rem Koolhaas / OMA*



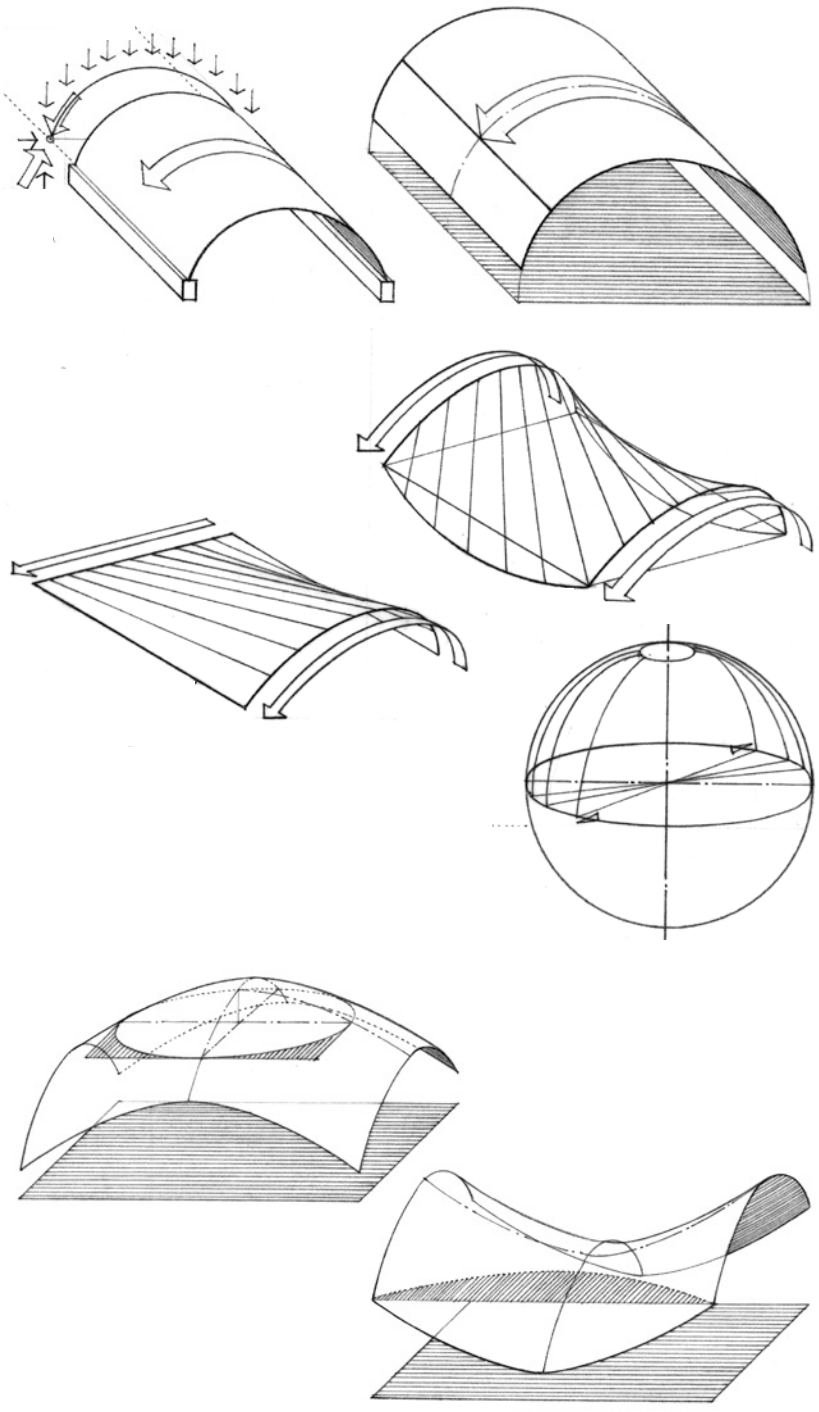
The key design issue is how prismatic forms, especially irregular ones, are able to accommodate the range of functional and spatial requirements within their volumes.



Hanamaruki Miso-Making Experience, Ina, Nagano, Japan, 2017, Takenaka Corporation

Frederic C. Hamilton Building, Denver Art Museum, Denver, Colorado, 2000–2006, Daniel Libeskind

GEOMETRIC TRANSFORMATION



Prismatic forms can be transformed by bending one or more of their planar faces, producing curved surfaces that are dynamic and capable of expressing flow and movement.

There is a special class of curved surfaces that can be generated from the geometric family of curves and straight lines. This class includes the following:

- Cylindrical surfaces are generated by sliding a straight line along a plane curve, or vice versa. Depending on the curve, a cylindrical surface may be circular, elliptic, or parabolic. Because of its straight line geometry, a cylindrical surface can be regarded as being either a translational or a ruled surface.

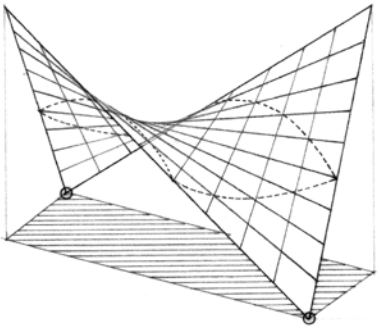
- Translational surfaces are generated by sliding a plane curve along a straight line or over another plane curve.

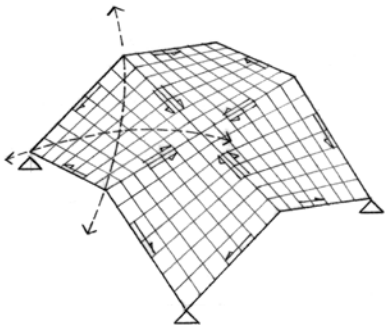
- Ruled surfaces are generated by the motion of a straight line. Because of its straight line geometry, a ruled surface is generally easier to form and construct than a rotational or translational surface.

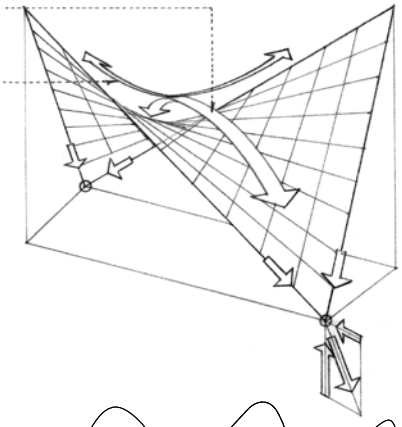
- Rotational surfaces are generated by rotating a plane curve about an axis.

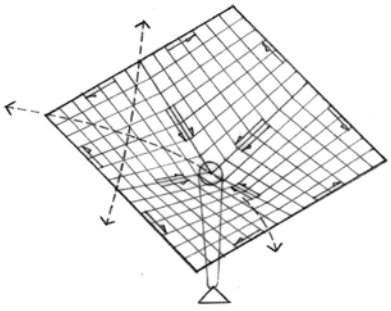
- Paraboloids are surfaces all of whose intersections by planes are either parabolas and ellipses or parabolas and hyperbolas. Parabolas are plane curves generated by a moving point that remains equidistant from a fixed line and a fixed point not on the line. Hyperbolas are plane curves formed by the intersection of a right circular cone with a plane that cuts both halves of the cone.
- Hyperbolic paraboloids are surfaces generated by sliding a parabola with downward curvature along a parabola with upward curvature, or by sliding a straight line segment with its ends on two skew lines. It can thus be considered to be both a translational and a ruled surface.

Saddle surfaces have an upward curvature in one direction and a downward curvature in the perpendicular direction. Regions of downward curvature exhibit archlike action while regions of upward curvature behave as a cable structure. If the edges of a saddle surface are not supported, beam behavior may also be present.

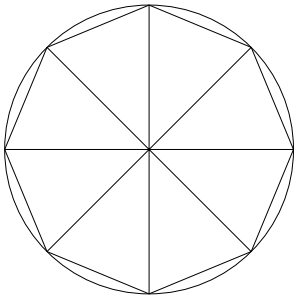


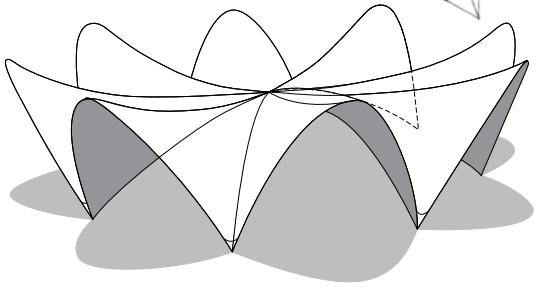






The type of structural system that can best take advantage of this doubly curved geometry is the shell structure—a thin, plate structure, usually of reinforced concrete, which is shaped to transmit applied forces by compressive, tensile, and shear stresses acting in the plane of the curved surface.

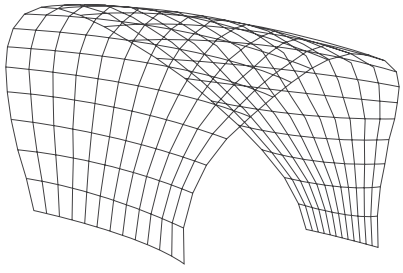


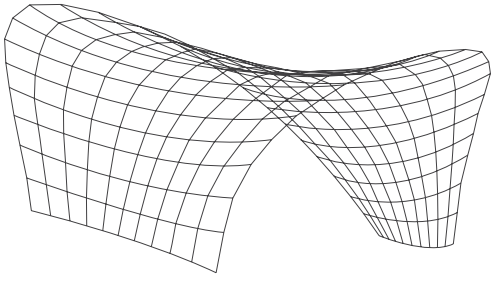


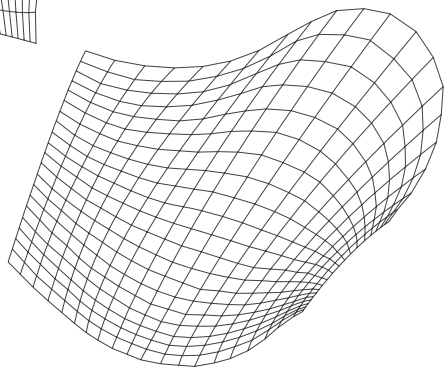
Restaurant Los Manantiales, Xochimilco, Mexico, 1958, Felix Candela. The structure consists of a radial arrangement of eight hyperbolic paraboloid segments.

Related to shell structures are gridshell structures, which were pioneered by the Russian engineer Vladimir Shukhov in the late-19th century. Like shell structures, gridshells rely on their double curvature geometry for their strength but are constructed of a grid or lattice, usually of wood or steel. Gridshells are capable of being formed into irregular curved surfaces, relying on computer modeling programs for their structural analysis and optimization, and sometimes their fabrication and assembly as well.

See also pages 192–193 for a related discussion of diagrid structures.



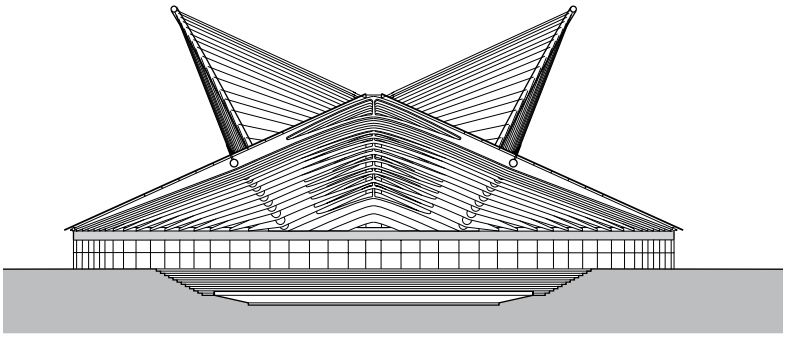




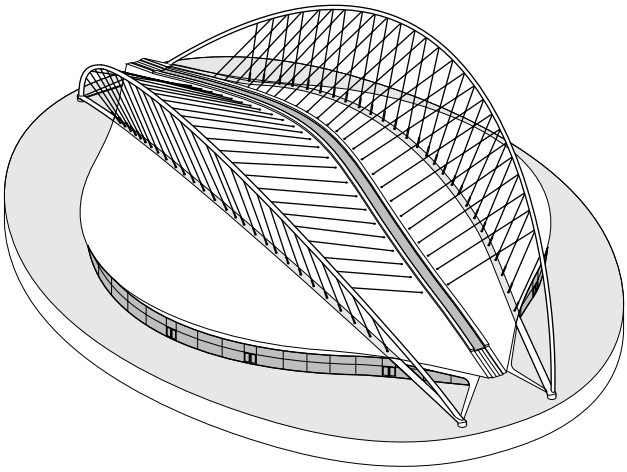
GEOMETRIC TRANSFORMATION

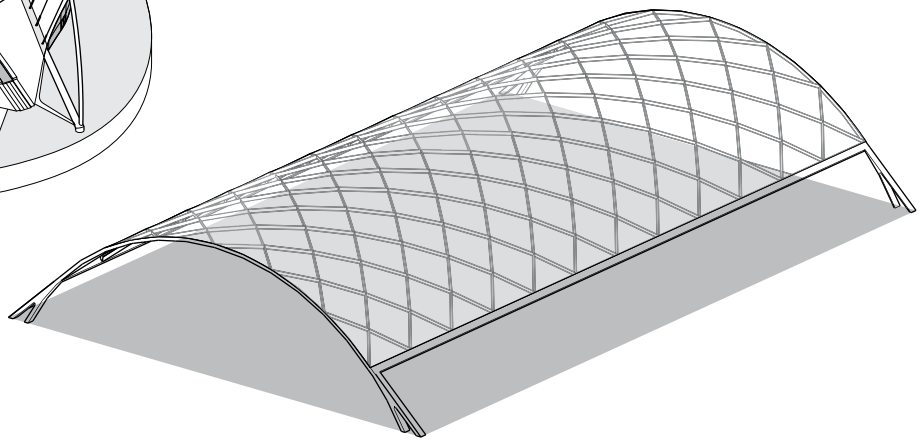
The fluid quality of curved surfaces contrasts with the angular nature of rectilinear forms and is appropriate for describing the form of shell structures as well as non-load-bearing elements of enclosure.

Symmetrical curved surfaces, such as barrel vaults and domes, are inherently stable.

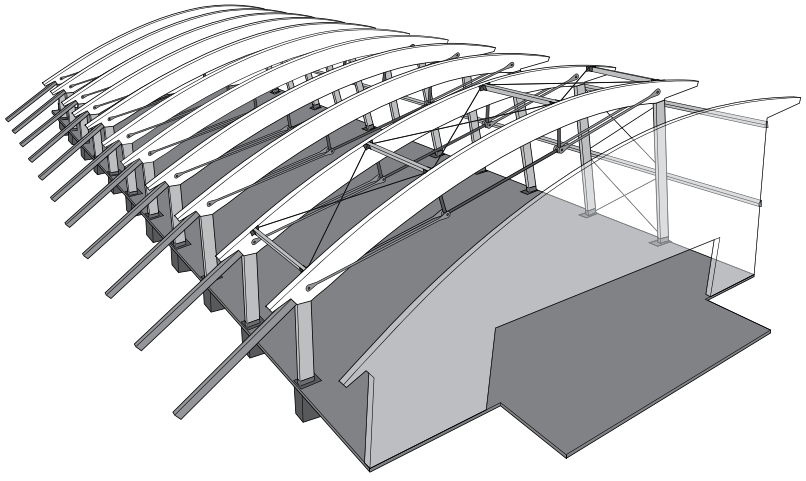


Olympic Velodrome, Athens, Greece, 2004 (renovation of original 1991 structure), Santiago Calatrava



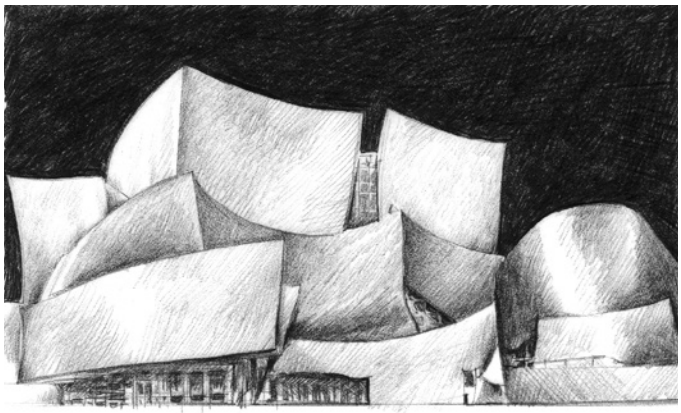


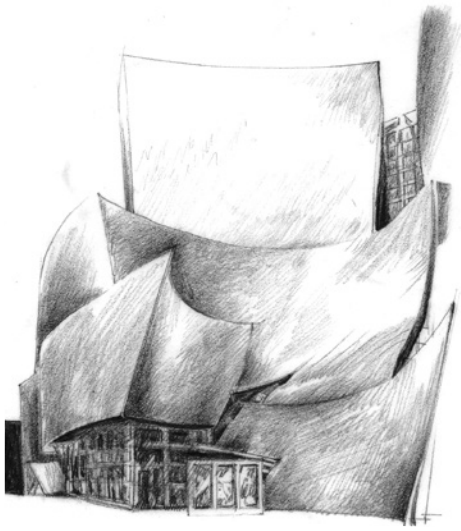
Lamella Vault. Lamella vaults are composed of relatively short timber or metal elements called lamellae, which form a crisscross pattern of parallel arches skewed with respect to the sides of the covered space.



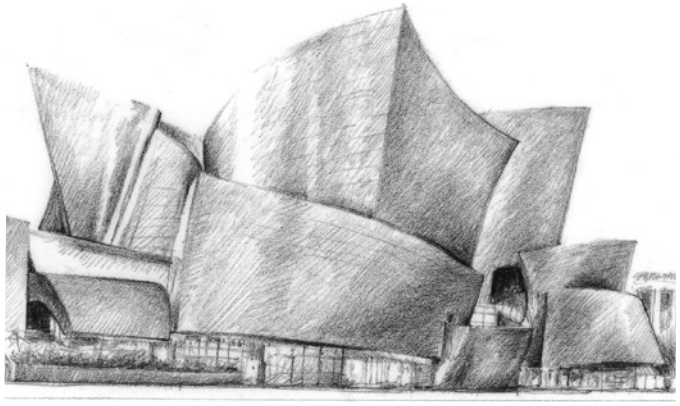
Banff Community Recreation Center, Banff, Alberta, Canada, 2011, GEC Architecture

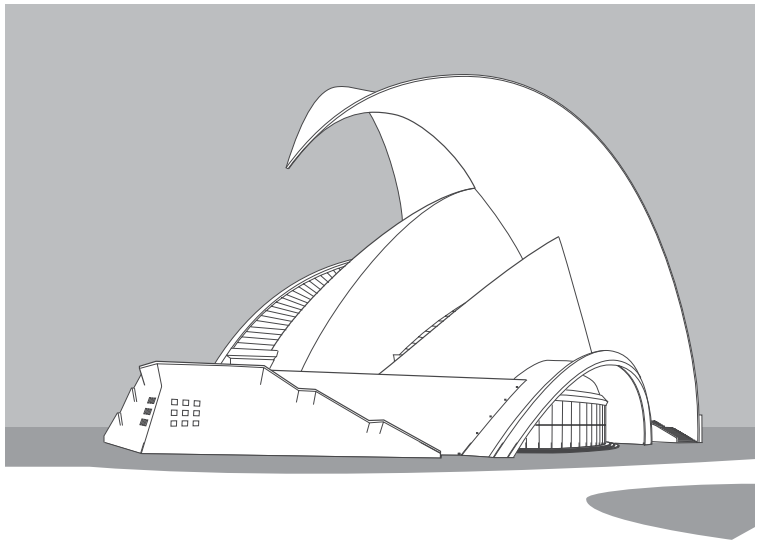
Asymmetrical curved surfaces, on the other hand, can be more vigorous and expressive in nature. Their shapes change dramatically as we view them from different perspectives.

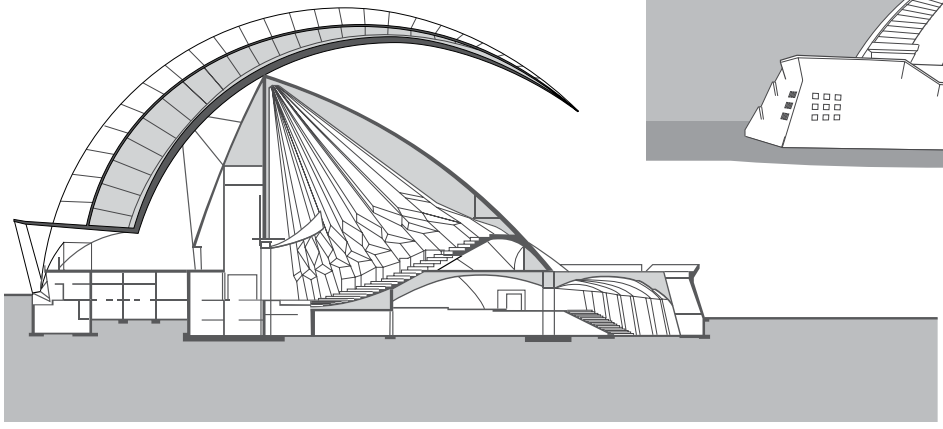




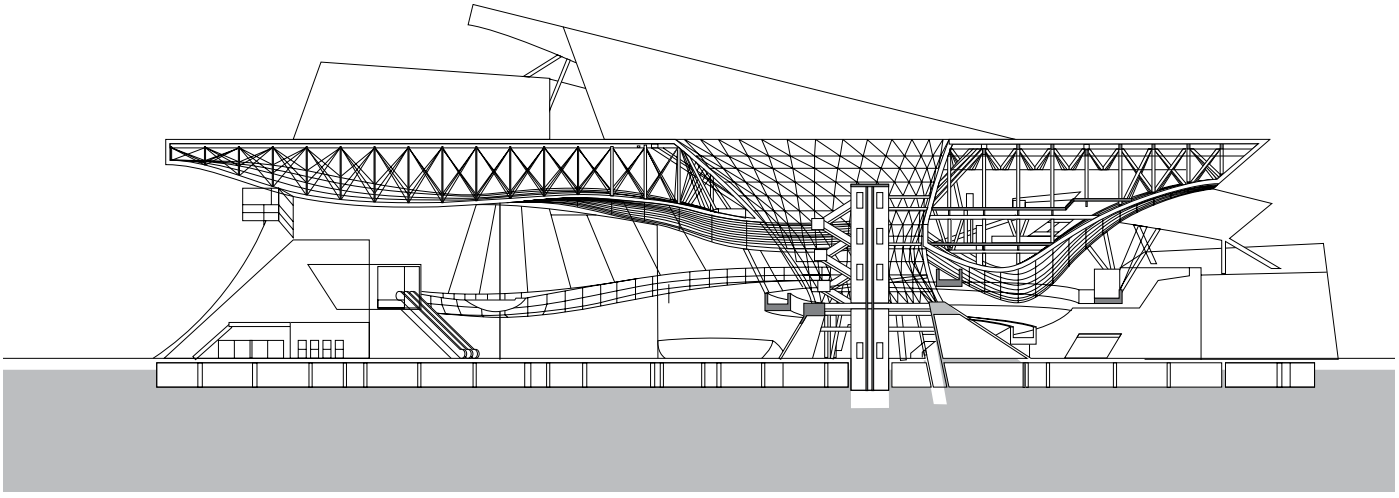
Walt Disney Concert Hall, Los Angeles, California, 1987–2003, Frank O. Gehry & Partners





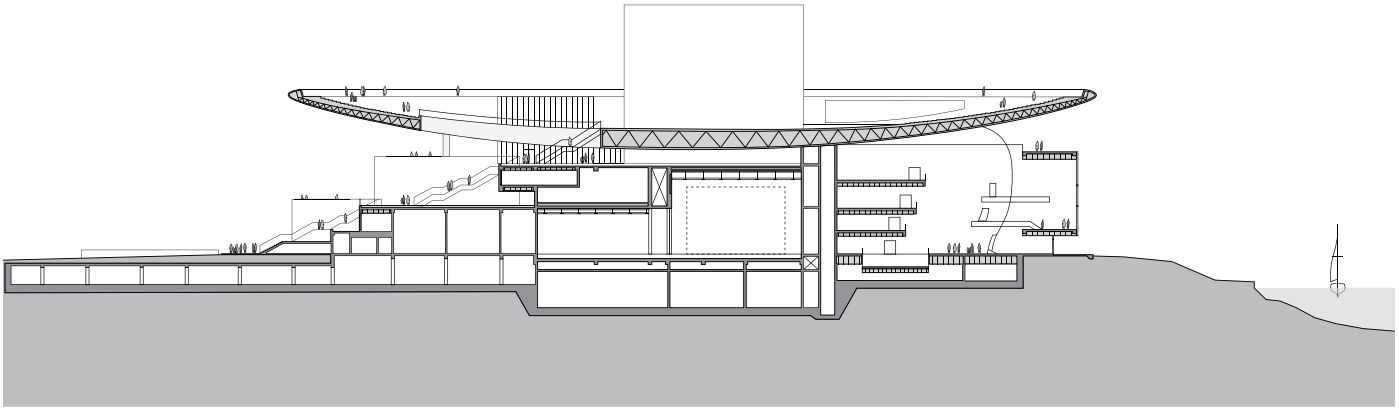


Tenerife Concert Hall, Canary Islands, Spain 1997–2003, Santiago Calatrava

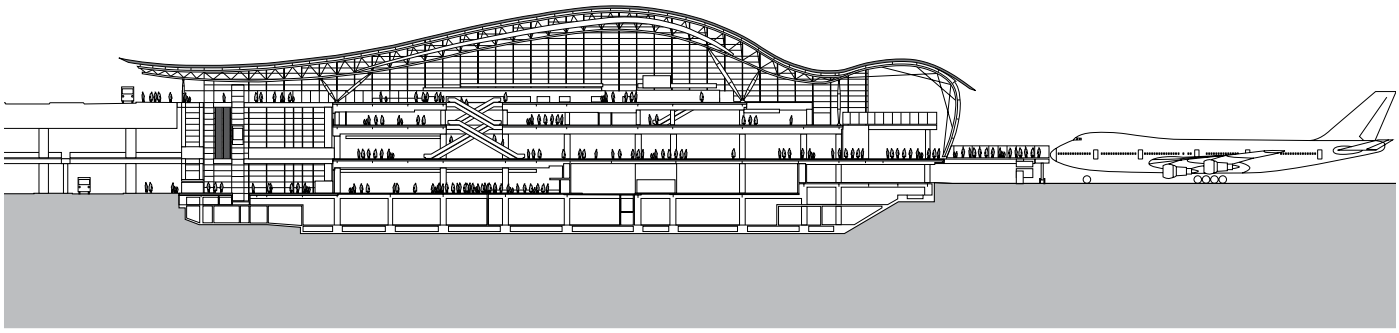


Busan Cinema Center, Busan, South Korea, 2012, COOP HIMMELB(l)au.
This example shows how irregular forms contrast with and play off of the horizontal ground and roof planes.

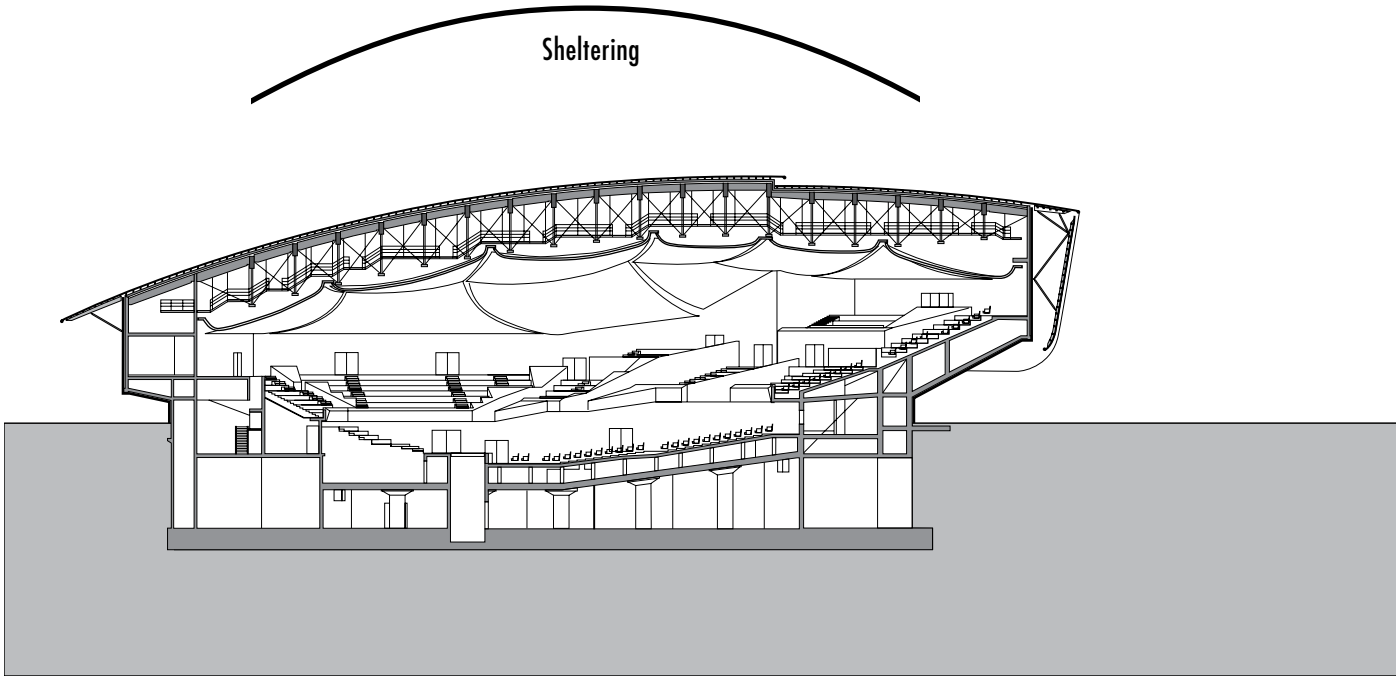
Uplifting



Busan Opera House (Proposal), Busan, Korea, Henning Larsen Architects + Tomoon Architects

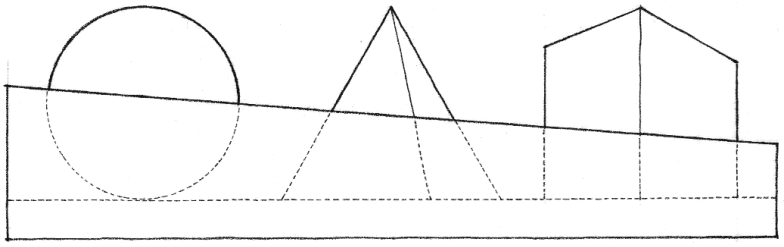


Kansai International Airport Terminal 1, Osaka Bay, Japan, 1988–1994, Renzo Piano Building Workshop in association with Nikken Sekkei Ltd and Ove Arup & Partners. The clear-span, undulating, asymmetrical roof hovering over the departure level was developed by Peter Rice and Tom Barker, Ove Arup's structural and services engineers respectively, to mimic the projected airflow clear across the space from the entry to the departure side.

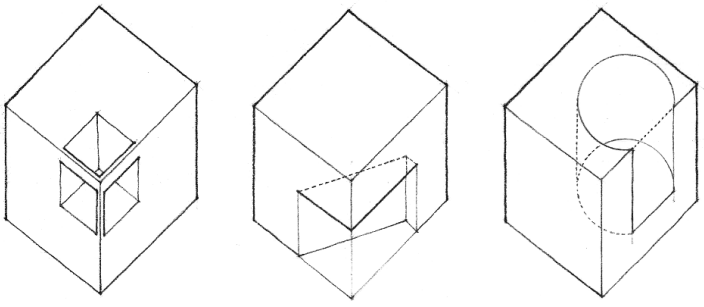


Parco della Musica, Rome, Italy, 2003, Renzo Piano (Acoustics: Jürgen Reinhold of Müller-BBM). This is a longitudinal section through the 2800-seat Sala Santa Cecilia, one of the three music halls comprising the Parco della Musica, situated north of Rome's historic center. The lead roof cladding appears to be sheltering the "soundbox" of the hall, which is conceived as a giant musical instrument.

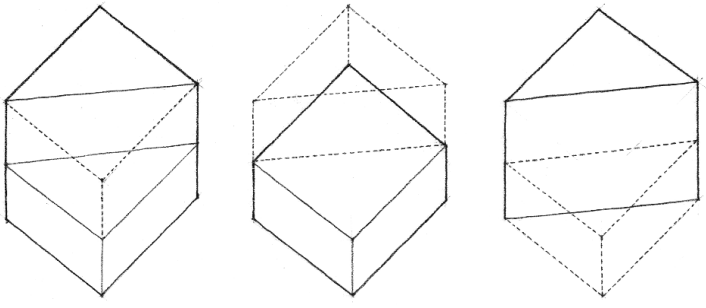
SUBTRACTIVE FORM



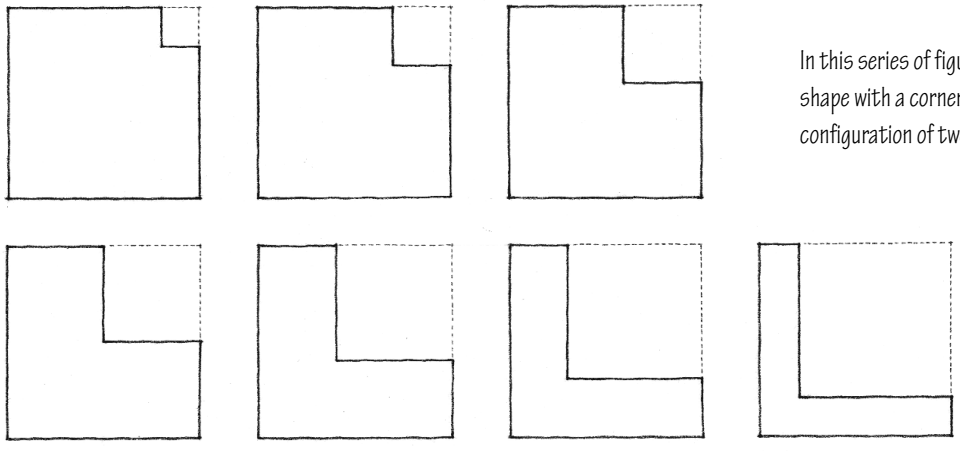
We search for regularity and continuity in the forms we see within our field of vision. If any of the primary solids is partially hidden from our view, we tend to complete its form and visualize it as if it were whole because the mind fills in what the eyes do not see. In a similar manner, when regular forms have fragments missing from their volumes, they retain their formal identities if we perceive them as incomplete wholes. We refer to these mutilated forms as subtractive forms.



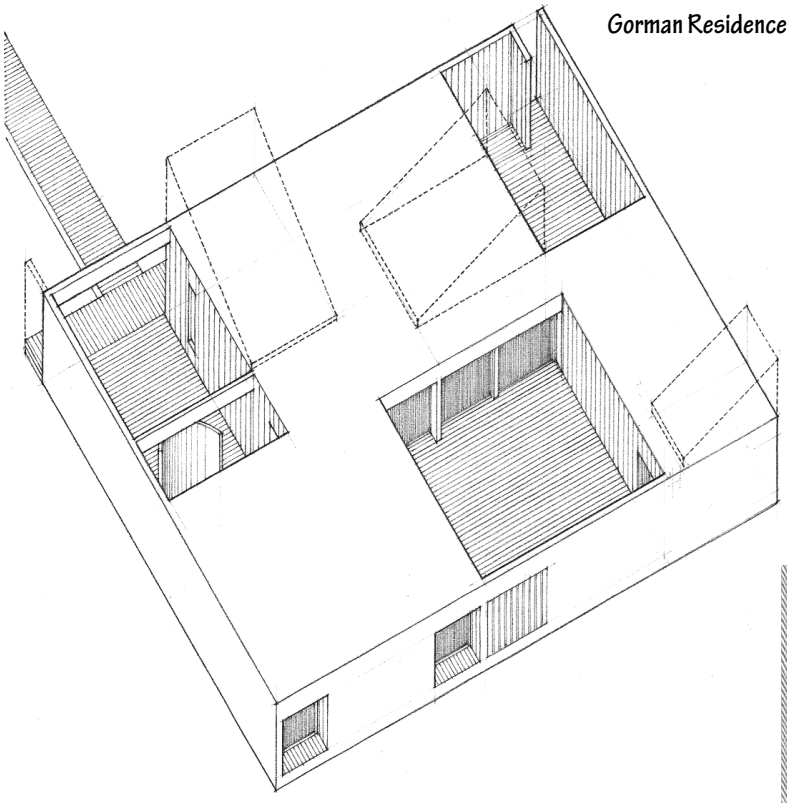
Because they are easily recognizable, simple geometric forms, such as the primary solids, adapt readily to subtractive treatment. These forms will retain their formal identities if portions of their volumes are removed without deteriorating their edges, corners, and overall profile.



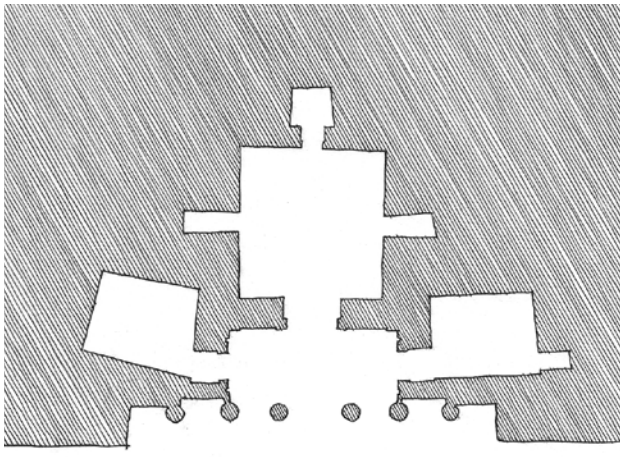
Ambiguity regarding the original identity of a form will result if the portion removed from its volume erodes its edges and drastically alters its profile.

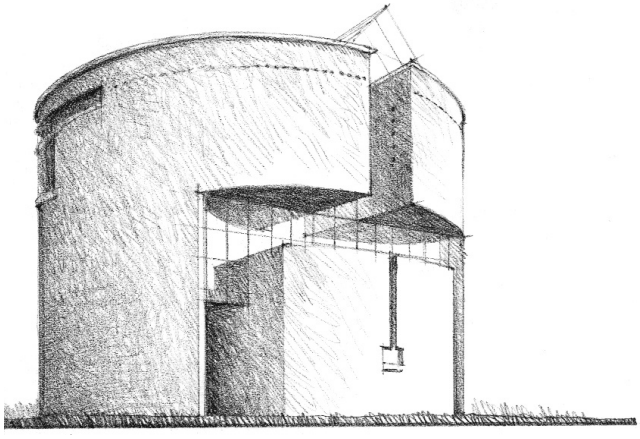


In this series of figures, at what point does the square shape with a corner portion removed become an L- shaped configuration of two rectangular planes?

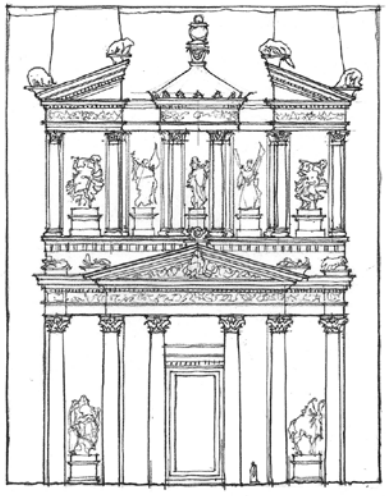


Gorman Residence, Amagansett, New York, 1968, Julian and Barbara Neski





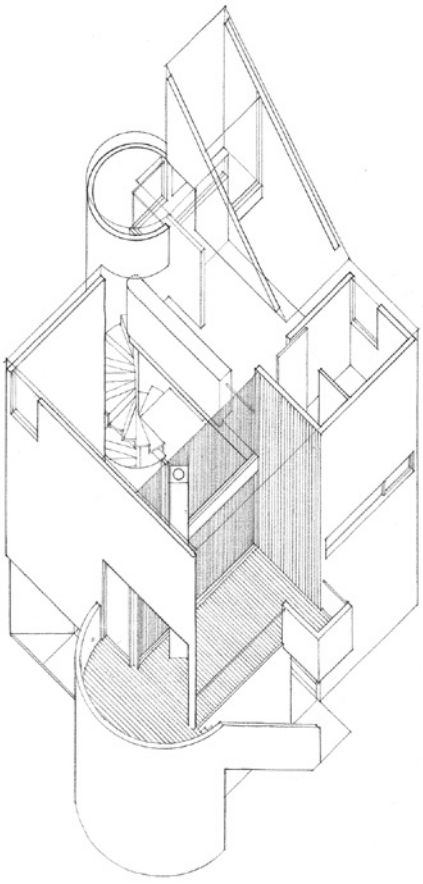
House at Stabio, Ticino, Switzerland, 1981, Mario Botta



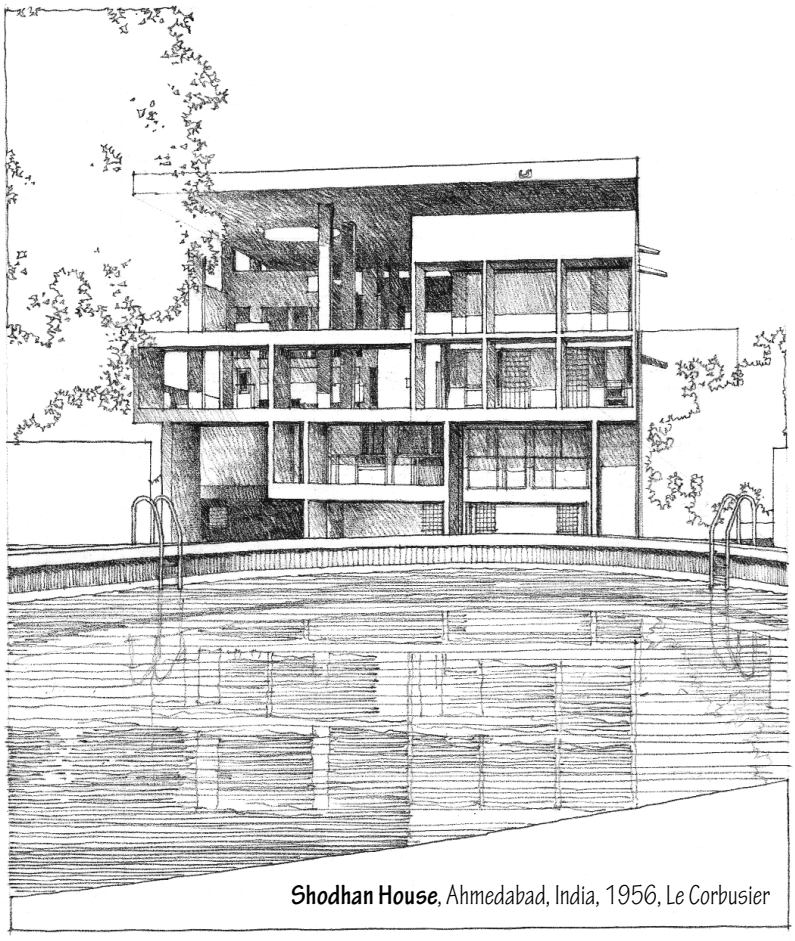
Khasneh al Faroun, Petra, 1st century A.D.

Spatial volumes may be subtracted from a form to create recessed entrances, positive courtyard spaces, or window openings shaded by the vertical and horizontal surfaces of the recess.

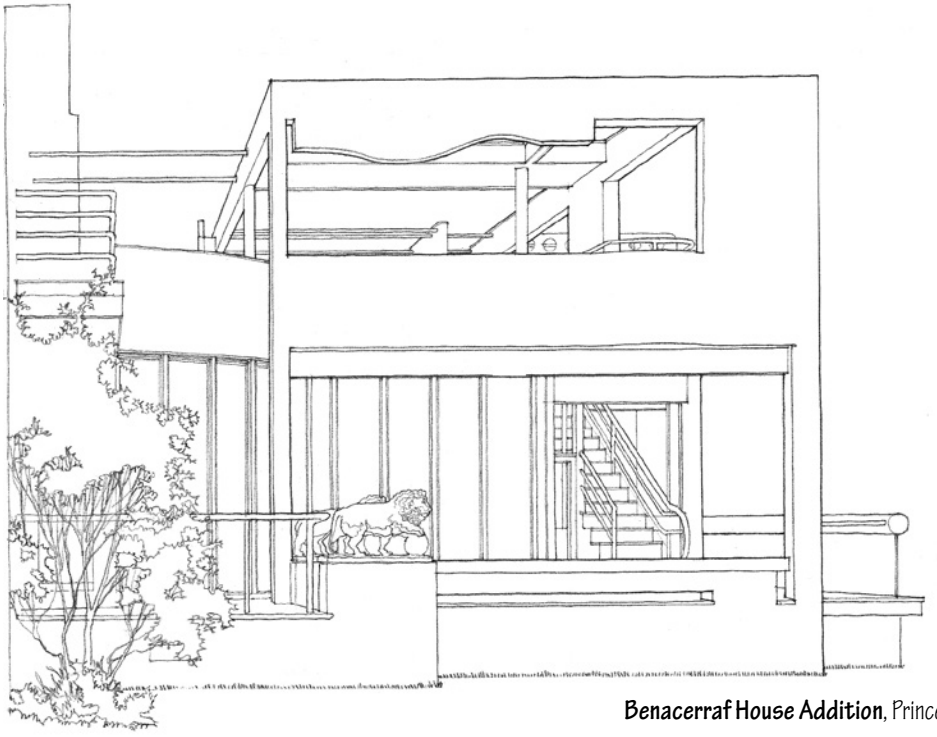
SUBTRACTIVE FORM



Gwathmey Residence, Amagansett, New York, 1967, Charles Gwathmey/Gwathmey Siegel & Associates



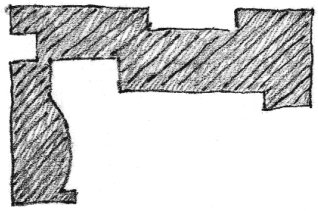
Shodhan House, Ahmedabad, India, 1956, Le Corbusier

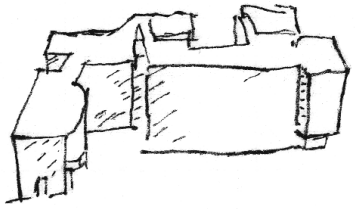


Benacerraf House Addition, Princeton, New Jersey, 1969, Michael Graves

Le Corbusier comments on form:

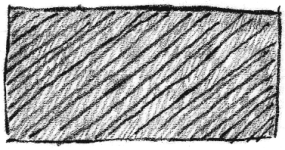
"Cumulative Composition
- Additive form
- A rather easy type
- Picturesque; full of movement
- Can be completely disciplined by classification and hierarchy"

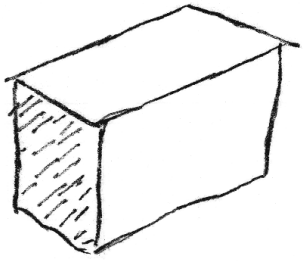




La Roche-Jeanneret Houses, Paris

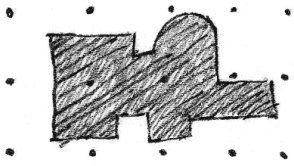
"Cubic Compositions (Pure Prisms)
- Very difficult (to satisfy the spirit)"

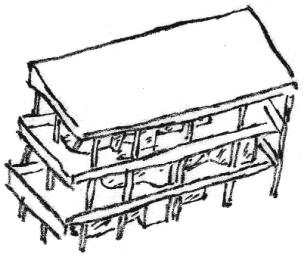




Villa at Garches

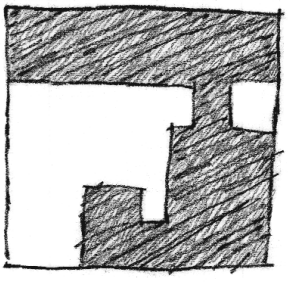
- "Very easy (convenient combining)"

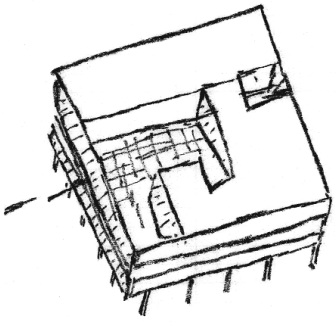




House at Stuttgart

"Subtractive Form
- Very generous
- On the exterior an architectural will is confirmed
- On the interior all functional needs are satisfied (light penetration, continuity, circulation)"

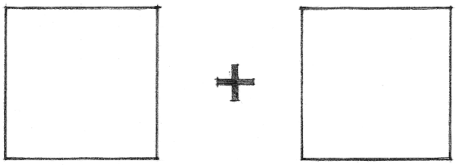




House at Poissy

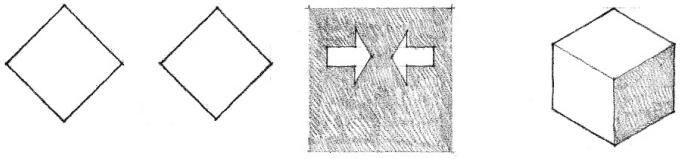
After a sketch, *Four House Forms*, by Le Corbusier for the cover of Volume Two of the *Oeuvre Complète*, published in 1935

ADDITIVE FORM



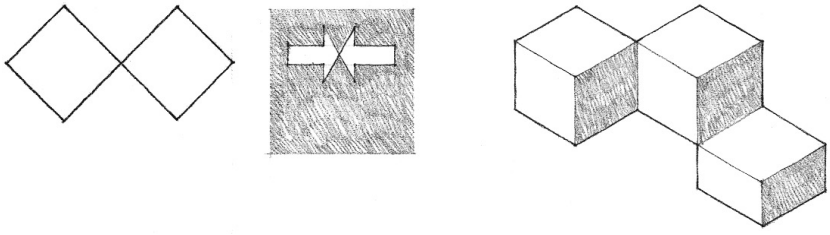
While a subtractive form results from the removal of a portion of its original volume, an additive form is produced by relating or physically attaching one or more subordinate forms to its volume.

The basic possibilities for grouping two or more forms are by:



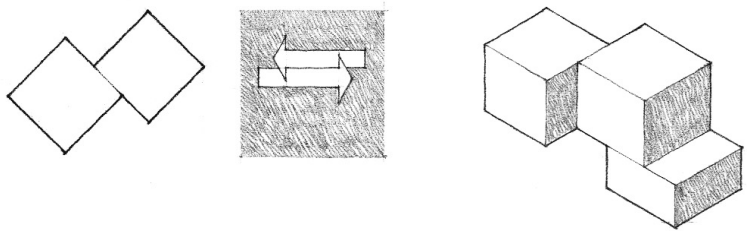
Spatial Tension

This type of relationship relies on the close proximity of the forms or their sharing of a common visual trait, such as shape, color, or material.



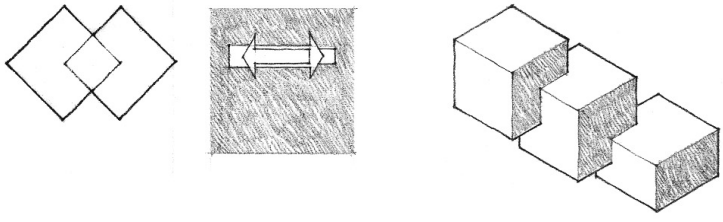
Edge-to-Edge Contact

In this type of relationship, the forms share a common edge and can pivot about that edge.



Face-to-Face Contact

This type of relationship requires that the two forms have corresponding planar surfaces which are parallel to each other.

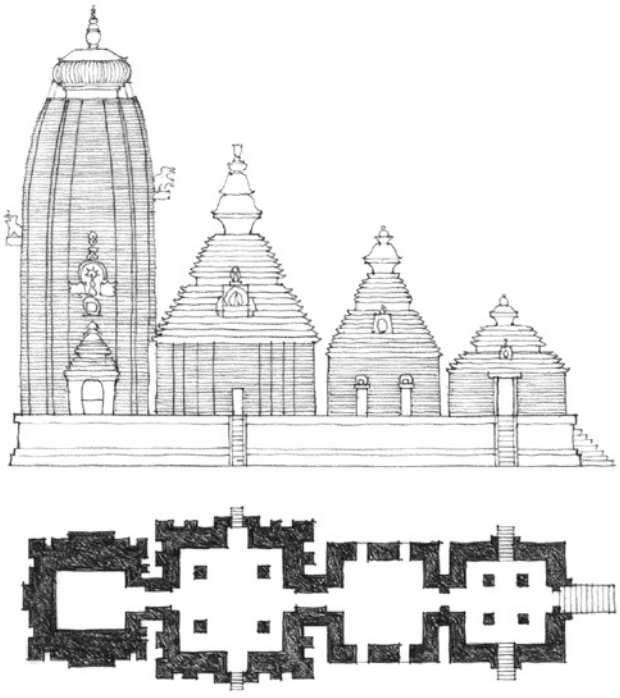


Interlocking Volumes

In this type of relationship, the forms interpenetrate each other's space. The forms need not share any visual traits.

Additive forms resulting from the accretion of discrete elements can be characterized by their ability to grow and merge with other forms. For us to perceive additive groupings as unified compositions of form—as figures in our visual field—the combining elements must be related to one another in a coherent manner.

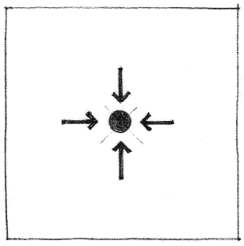
These diagrams categorize additive forms according to the nature of the relationships that exist among the component forms as well as their overall configurations. This outline of formal organizations should be compared with a parallel discussion of spatial organizations in Chapter 4.



Lingaraja Temple, Bhubaneshwar, India, c. A.D. 1100

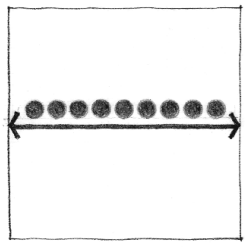
Centralized Form

A number of secondary forms clustered about a dominant, central parent-form



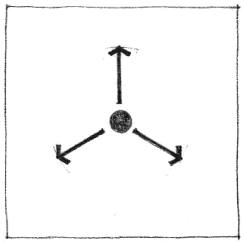
Linear Form

A series of forms arranged sequentially in a row



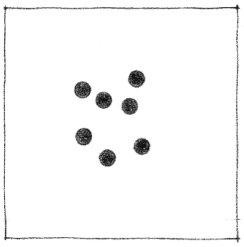
Radial Form

A composition of linear forms extending outward from a central form in a radial manner



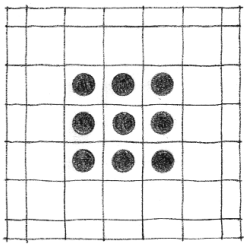
Clustered Form

A collection of forms grouped together by proximity or the sharing of a common visual trait

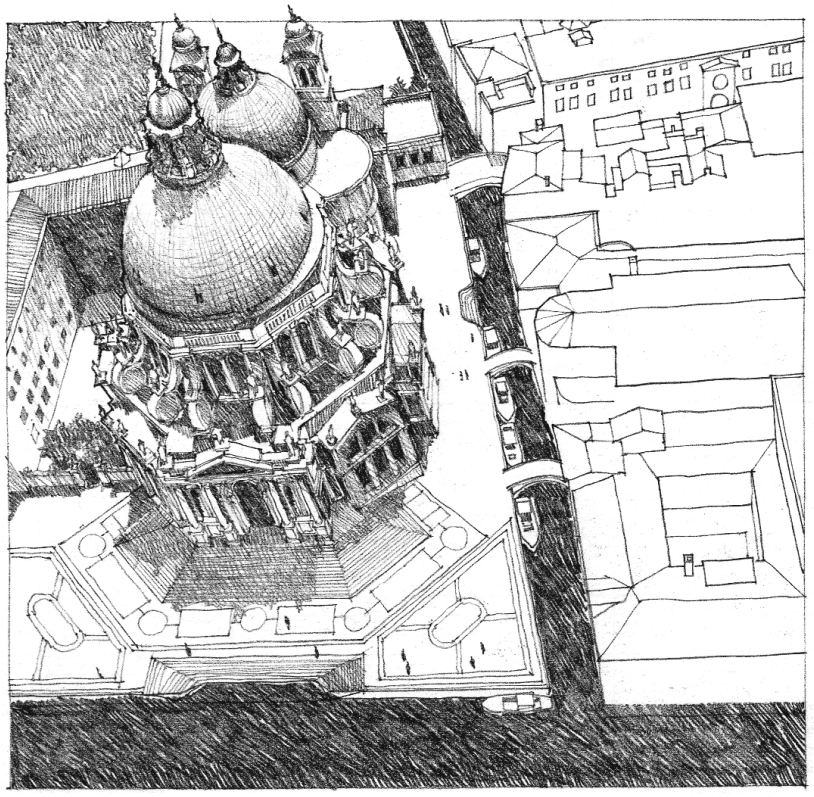


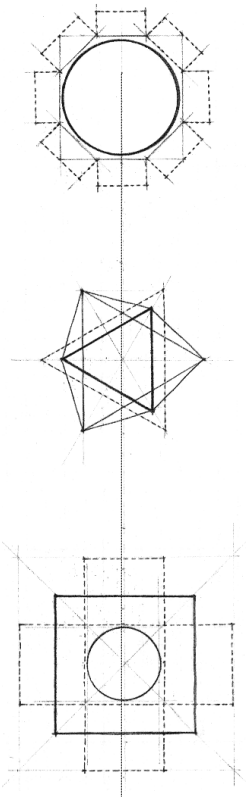
Grid Form

A set of modular forms related and regulated by a three-dimensional grid

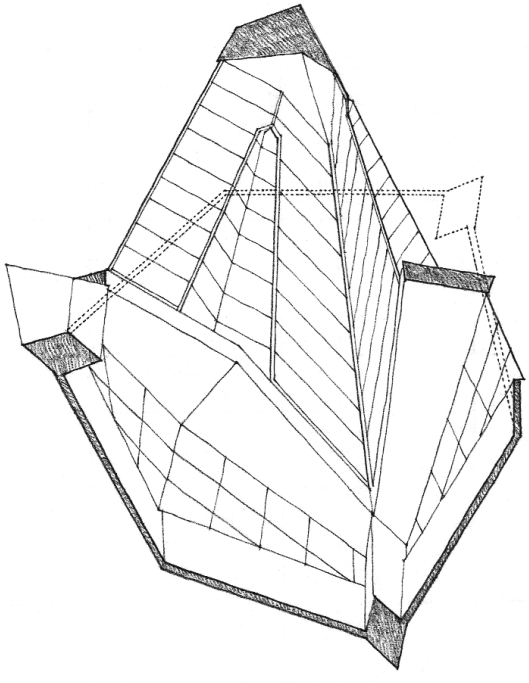


CENTRALIZED FORM

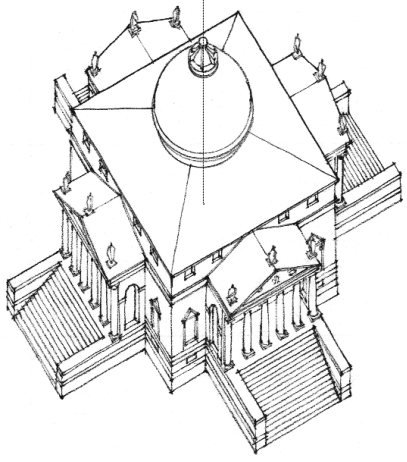




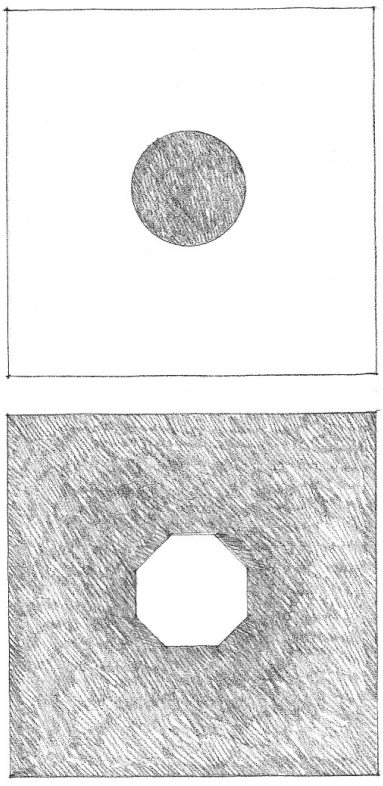
St. Maria Della Salute, *Venice, 1631–1682, Baldassare Longhena*

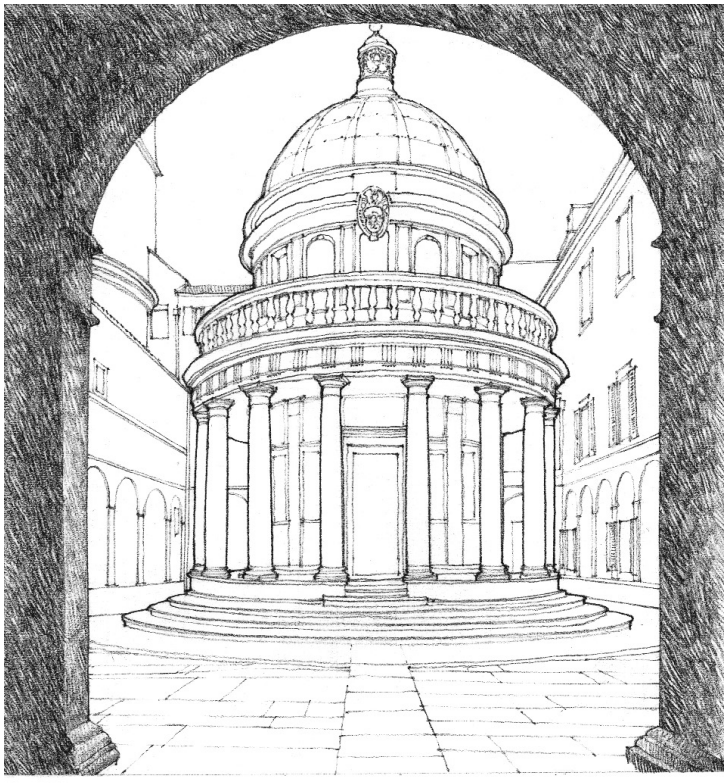


Beth Sholom Synagogue, Elkins Park, Pennsylvania, 1959, Frank Lloyd Wright



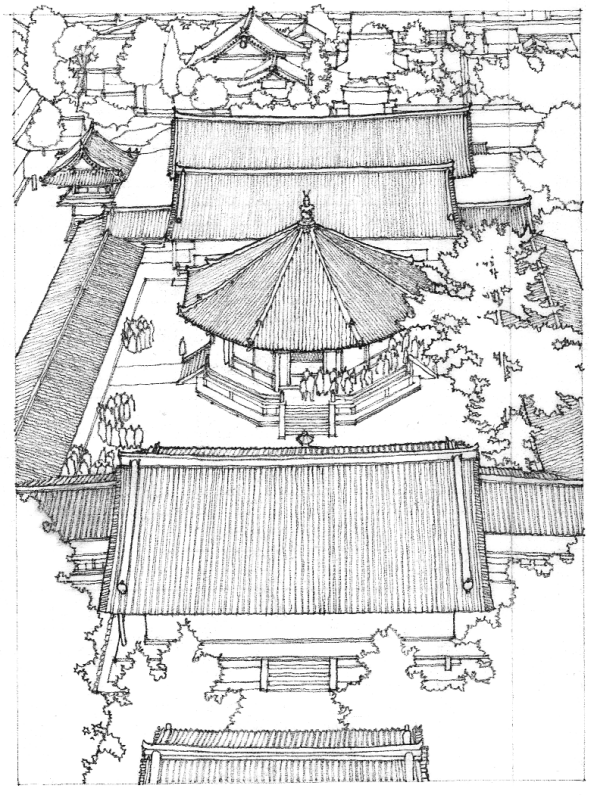
Villa Capra (The Rotunda), *Vicenza, Italy, 1552–1567, Andrea Palladio*





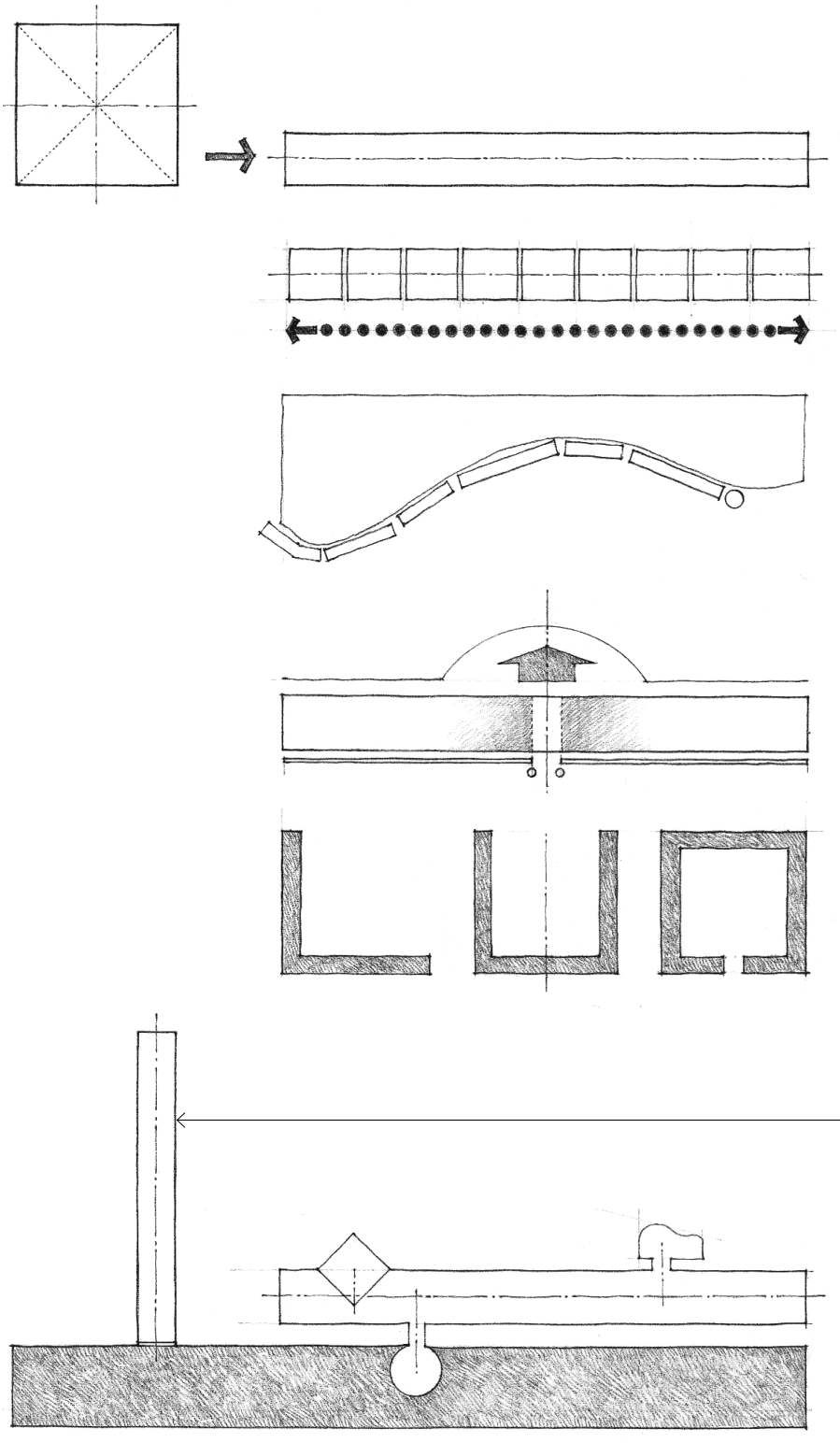
Tempietto, S. Pietro in Montorio, Rome, 1502, Donato Bramante

Centralized forms require the visual dominance of a geometrically regular, centrally located form, such as a sphere, cone, or cylinder. Because of their inherent centrality, these forms share the self-centering properties of the point and circle. They are ideal as freestanding structures isolated within their context, dominating a point in space, or occupying the center of a defined field. They can embody sacred or honorific places, or commemorate significant persons or events.



Yume-Dono, Eastern precinct of Horyu-Ji Temple, Nara, Japan, A.D. 607

LINEAR FORM



- A linear form can result from a proportional change in a form's dimensions or the arrangement of a series of discrete forms along a line. In the latter case, the series of forms may be either repetitive or dissimilar in nature and organized by a separate and distinct element such as a wall or path.

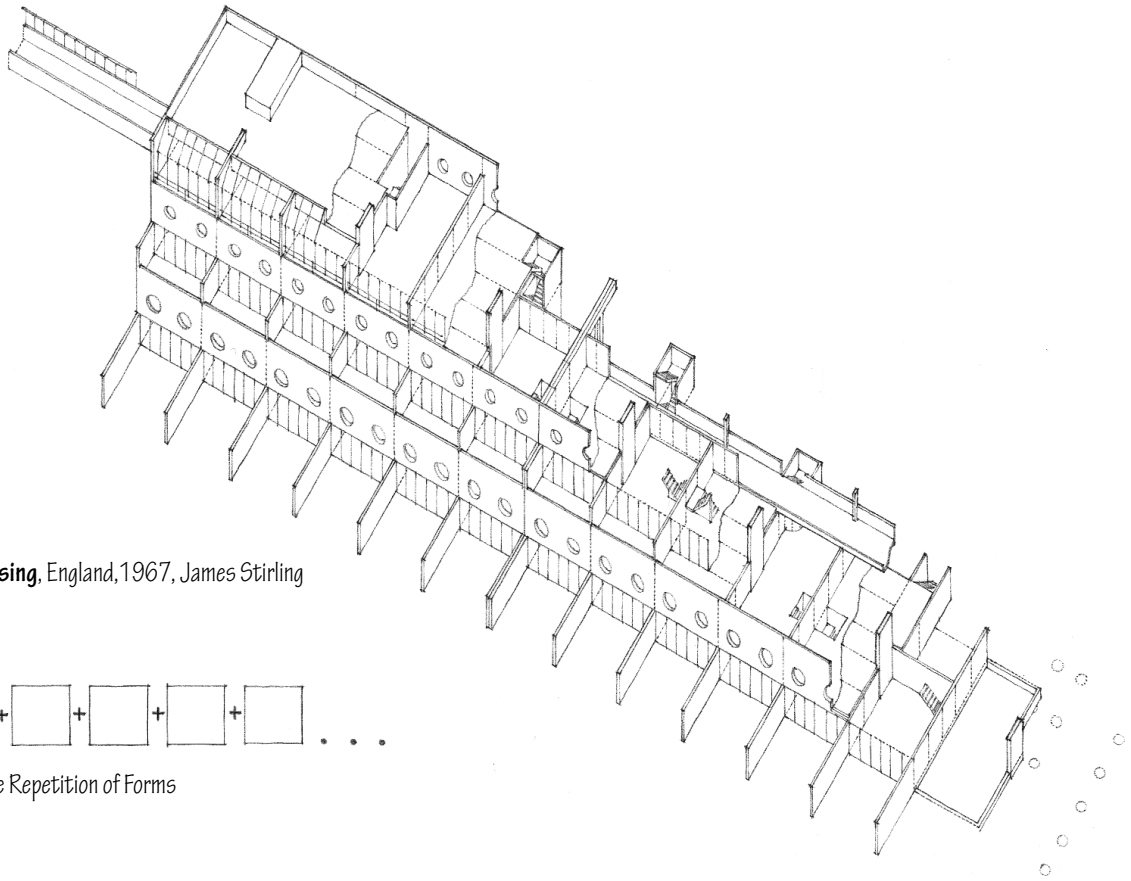
- A linear form can be segmented or curvilinear to respond to topography, vegetation, views, or other features of a site.

- A linear form can front on or define an edge of an exterior space, or define a plane of entry into the spaces behind it.

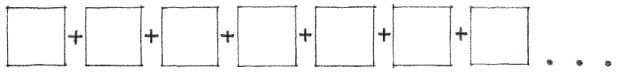
- A linear form can be manipulated to enclose a portion of space.

- A linear form can be oriented vertically as a tower element to establish or denote a point in space.

- A linear form can serve as an organizing element to which a variety of secondary forms are attached.

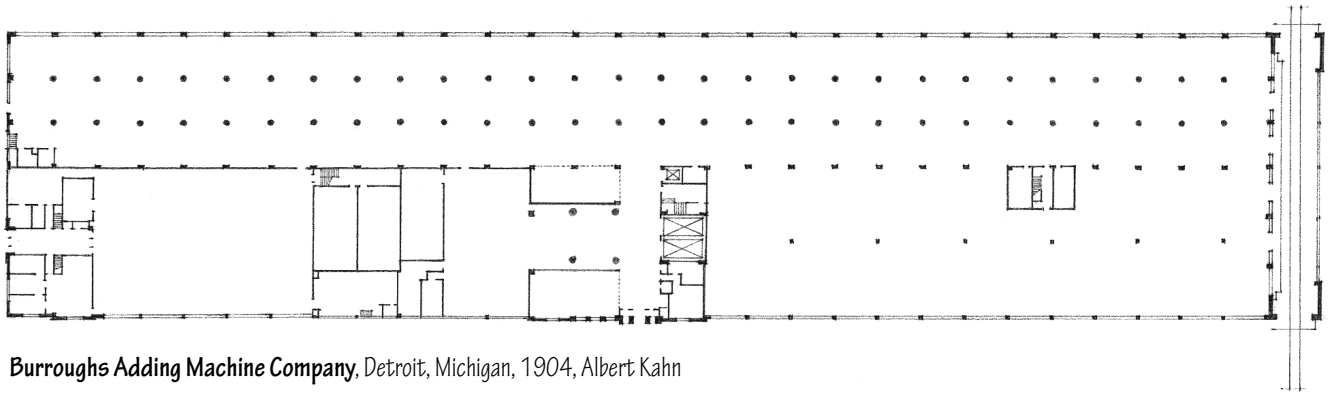


Runcorn New Town Housing, England, 1967, James Stirling



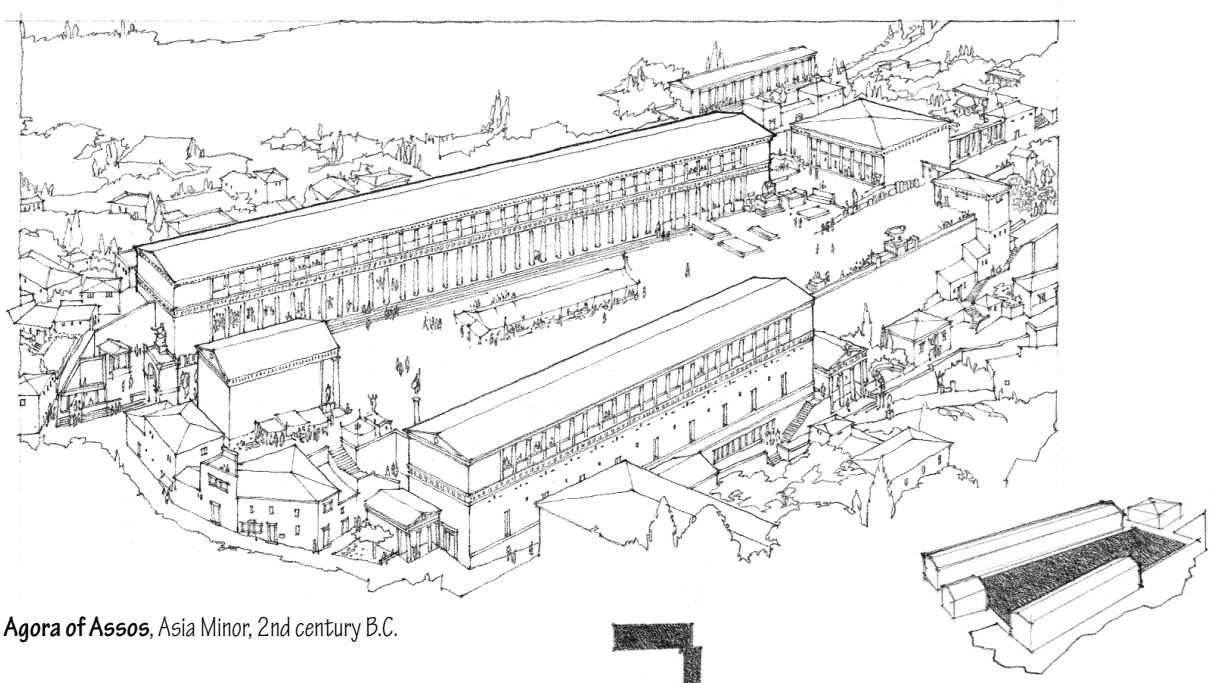
Linear Growth through the Repetition of Forms

Linear Form Expressing Procession or Movement

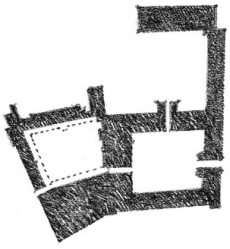


Burroughs Adding Machine Company, Detroit, Michigan, 1904, Albert Kahn

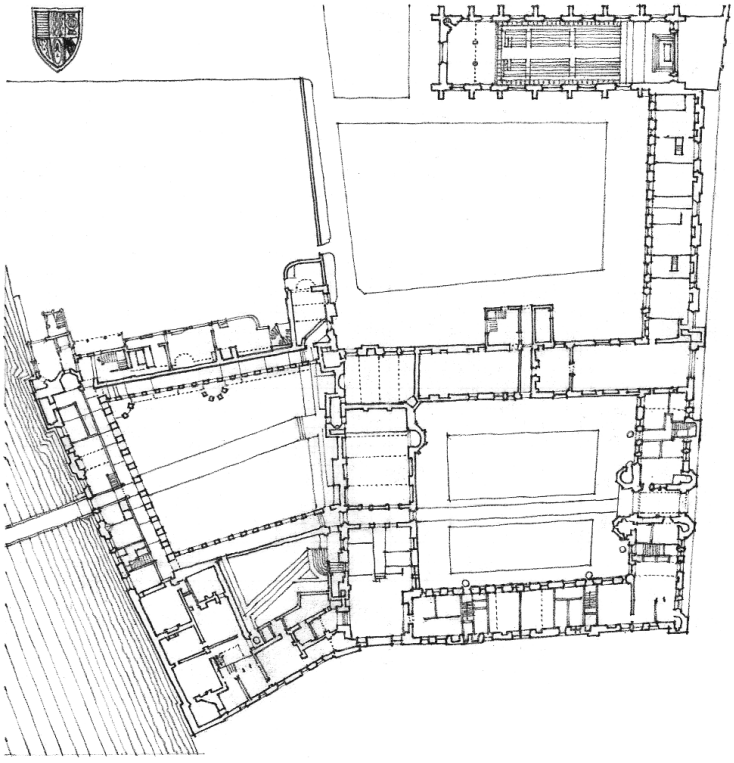
LINEAR FORM



Agora of Assos, Asia Minor, 2nd century B.C.



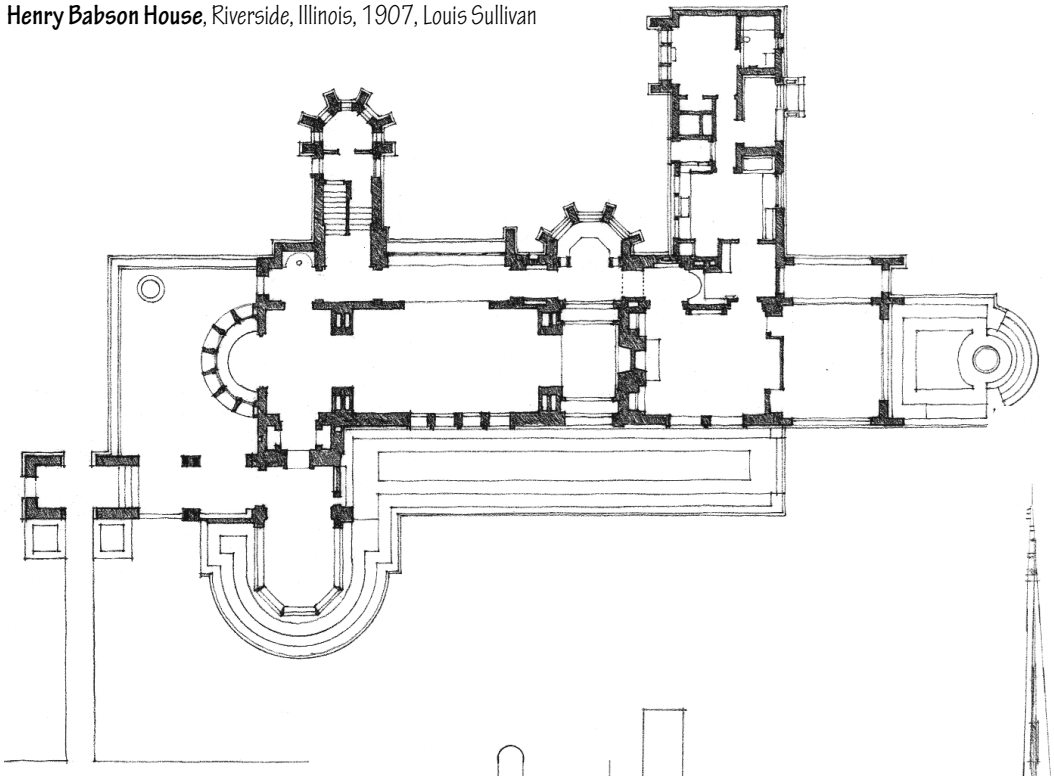
Linear Forms Fronting on or Defining Exterior Space



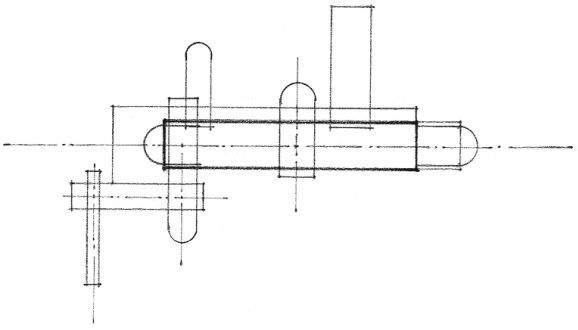
Queen's College, Cambridge, England, 1709–1738, Nicholas Hawksmoor

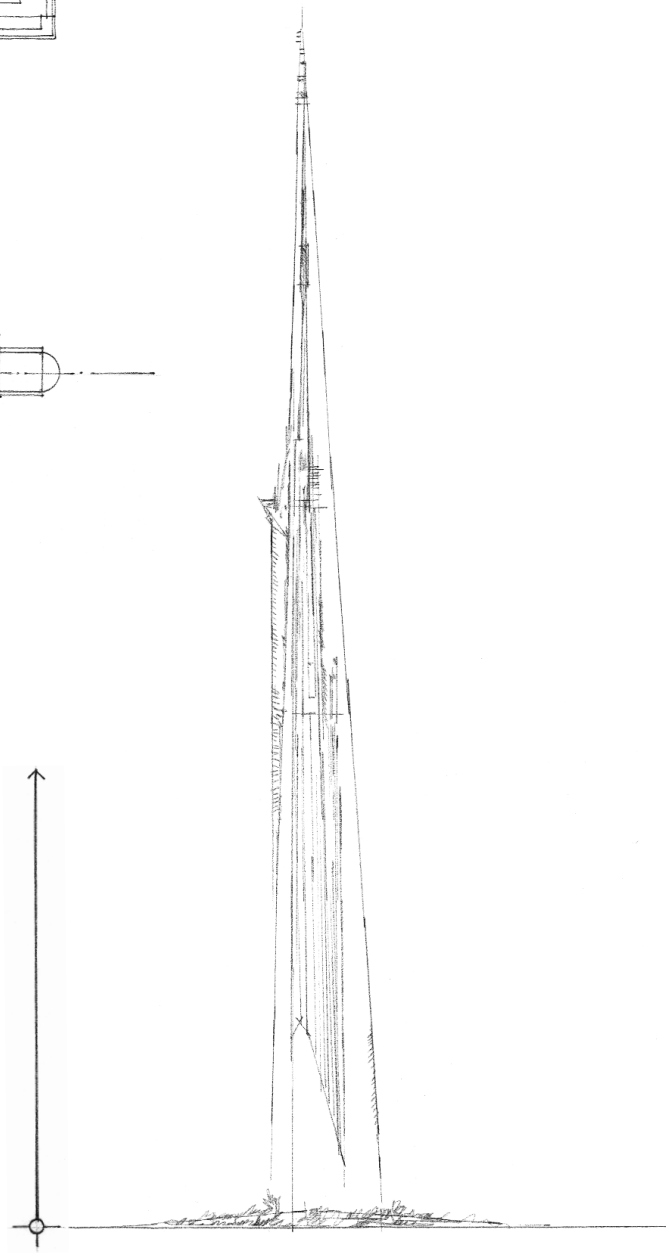
18th-century buildings fronting a tree-lined canal in Kampen, Holland

Henry Babson House, *Riverside, Illinois, 1907, Louis Sullivan*



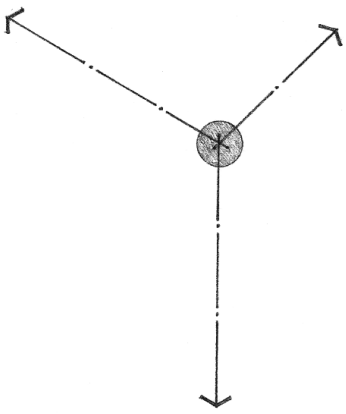
Linear Organizations of Space



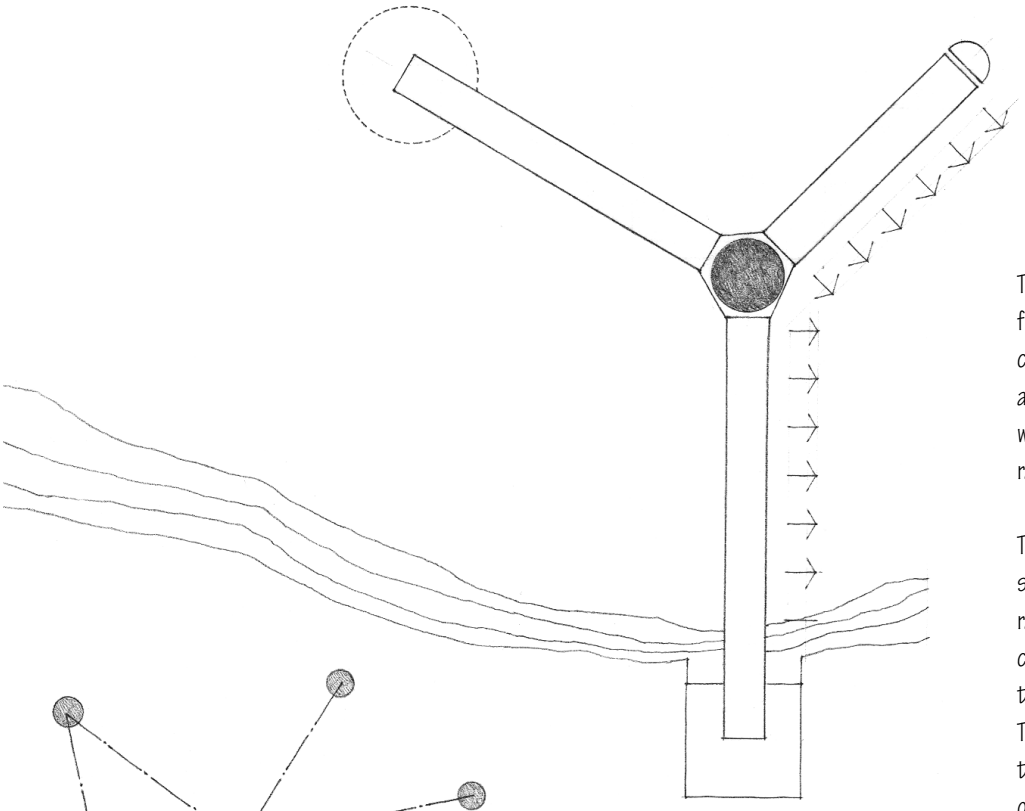


Mile-High Illinois Skyscraper Project, *Chicago, Illinois, 1956, Frank Lloyd Wright*

RADIAL FORM

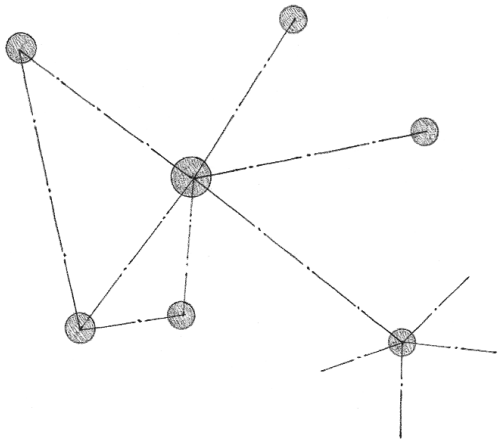


A radial form consists of linear forms that extend outward from a centrally located core element in a radiating manner. It combines the aspects of centrality and linearity into a single composition.

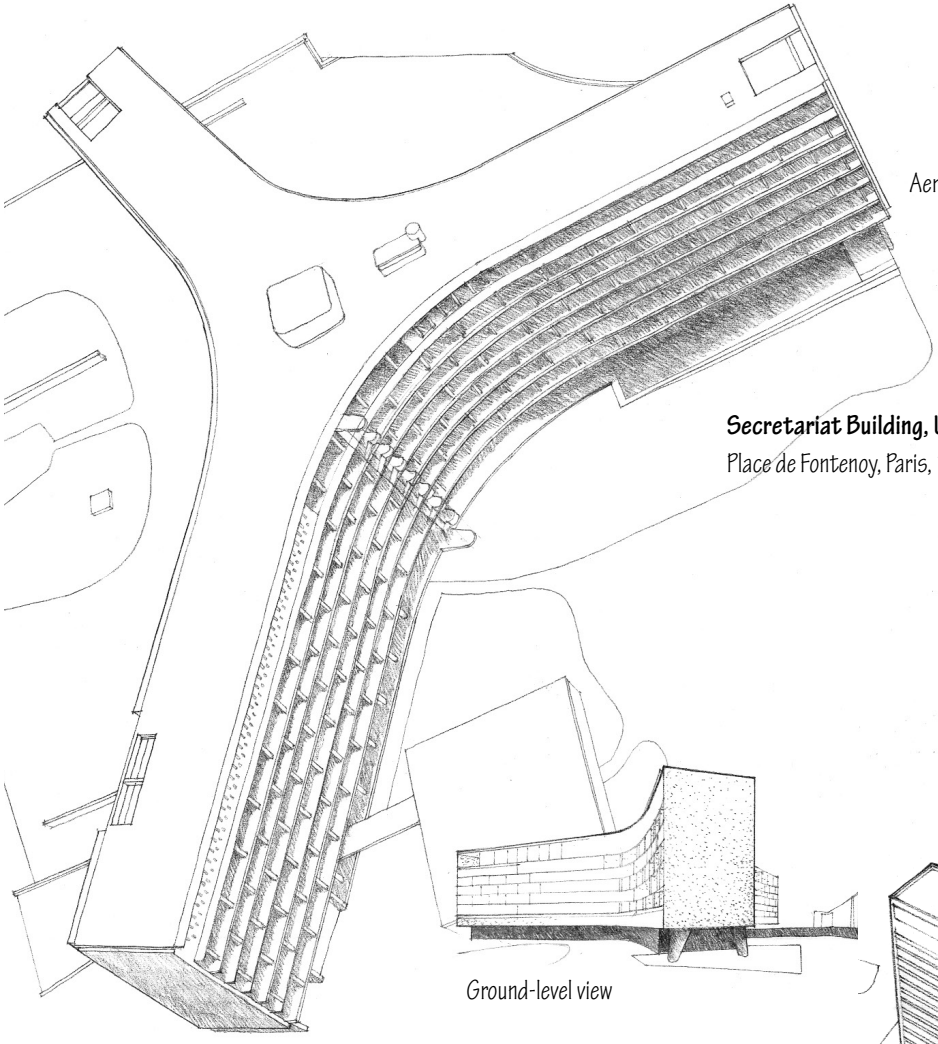


The core is either the symbolic or functional center of the organization. Its central position can be articulated with a visually dominant form, or it can merge with and become subservient to the radiating arms.

The radiating arms, having properties similar to those of linear forms, give a radial form its extroverted nature. They can reach out and relate to or attach themselves to specific features of a site. They can expose their elongated surfaces to desirable conditions of sun, wind, view, or space.



Radial forms can grow into a network of centers linked by linear arms.

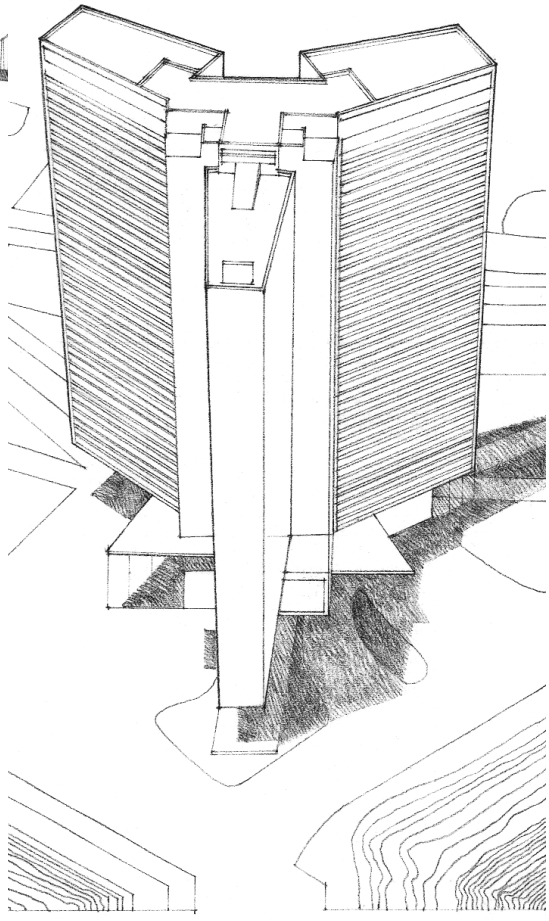


Aerial view

Secretariat Building, UNESCO Headquarters,
Place de Fontenoy, Paris, 1953–1958, Marcel Breuer

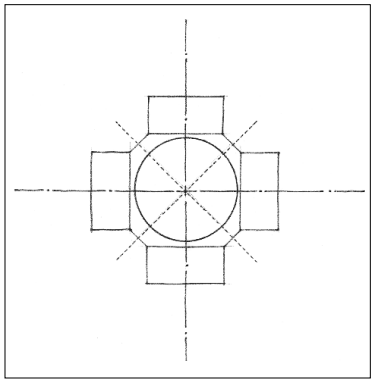
Ground-level view

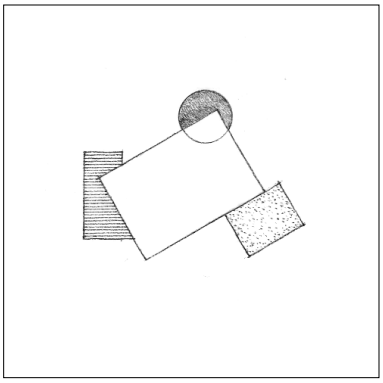
The organization of a radial form can best be seen and understood from an aerial viewpoint. When viewed from ground level, its central core element may not be clearly visible and the radiating pattern of its linear arms may be obscured or distorted through perspective foreshortening.

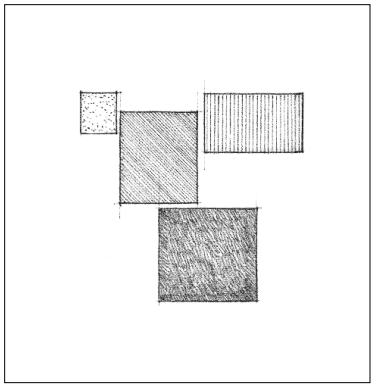


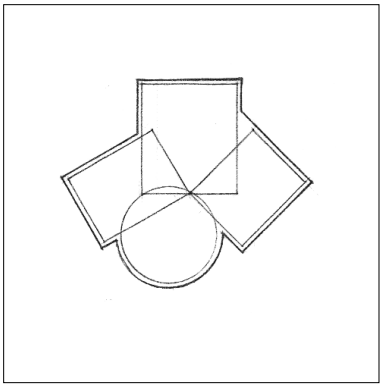
Skyscraper by the Sea, Project for Algiers, 1938, Le Corbusier

CLUSTERED FORM





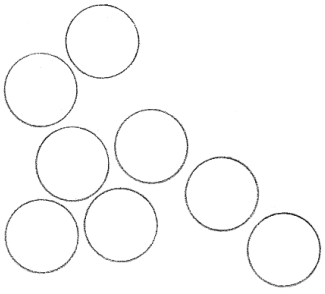


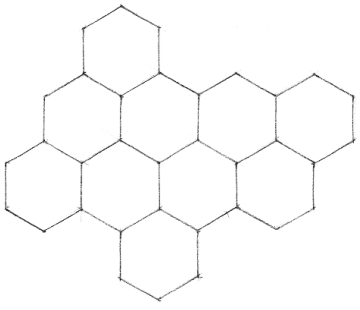


While a centralized organization has a strong geometric basis for the ordering of its forms, a clustered organization groups its forms according to functional requirements of size, shape, or proximity. While it lacks the geometric regularity and introverted nature of centralized forms, a clustered organization is flexible enough to incorporate forms of various shapes, sizes, and orientations into its structure.

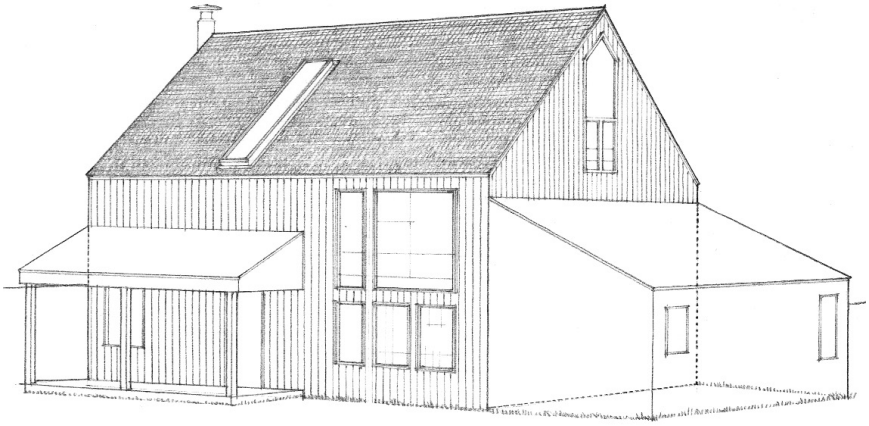
Considering their flexibility, clustered organizations of forms may be organized in the following ways:

- They can be attached as appendages to a larger parent form or space.
- They can be related by proximity alone to articulate and express their volumes as individual entities.
- They can interlock their volumes and merge into a single form having a variety of faces.





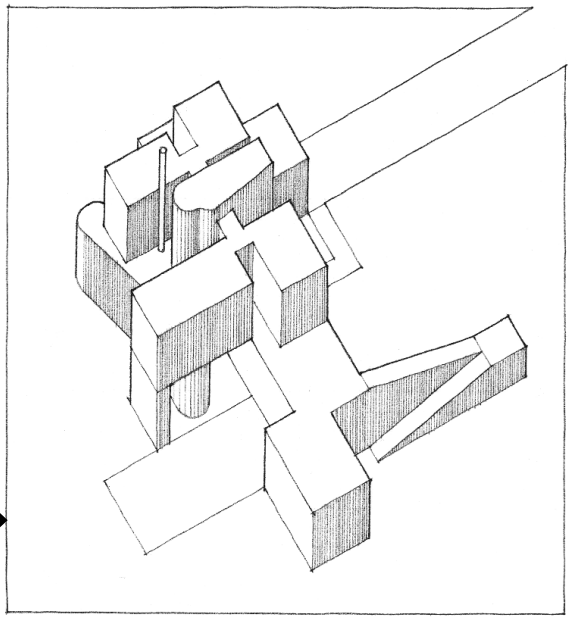
A clustered organization can also consist of forms that are generally equivalent in size, shape, and function. These forms are visually ordered into a coherent, nonhierarchical organization not only by their close proximity to one another, but also by the similarity of their visual properties.



A Cluster of Forms Attached to a Parent Form:
Vacation House, *Sea Ranch, California, 1968, MLTW*

A Cluster of Interlocking Forms:
G.N. Black House (Kragsyde)*, Manchester-by-the Sea, Massachusetts, 1882–1883, Peabody & Stearns*

A Cluster of Articulated Forms:
House Study*, 1956, James Stirling & James Gowan* →

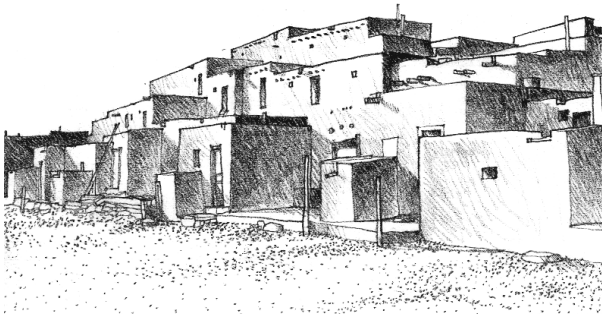


CLUSTERED FORM

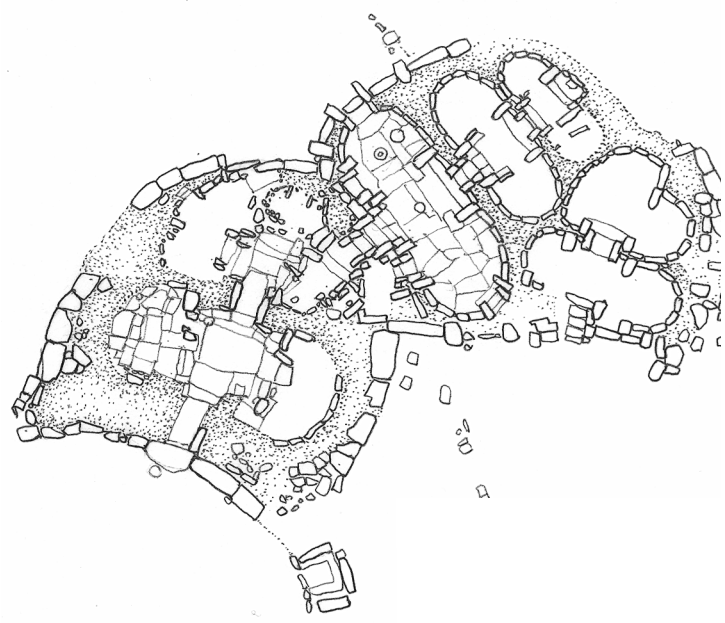
Trulli Village, Alberobello, Italy
Traditional dry-stone shelters in existence since the 17th century.

Numerous examples of clustered housing forms can be found in the vernacular architecture of various cultures. Even though each culture produced a unique style in response to differing technical, climatic, and sociocultural factors, these clustered housing organizations usually maintained the individuality of each unit and a moderate degree of diversity within the context of an ordered whole.

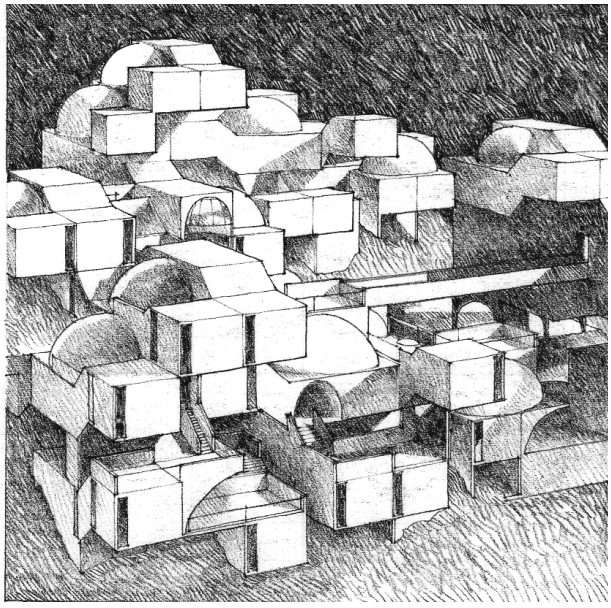
Dogon Housing Cluster, Southeastern Mali, West Africa, 15th century–present



Taos Pueblo, New Mexico, 13th century

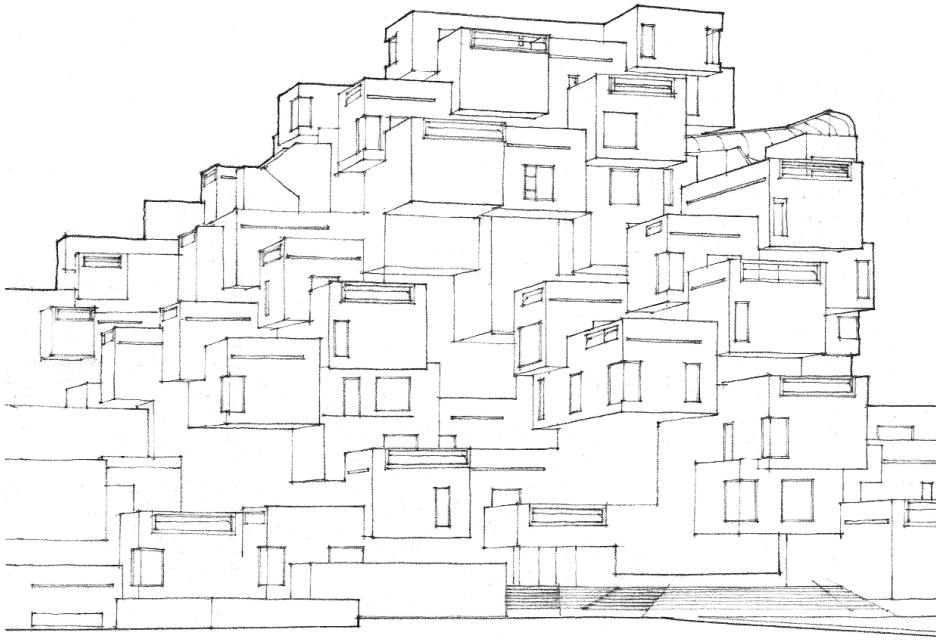


Ggantija Temple Complex, Malta, c. 3000 B.C.



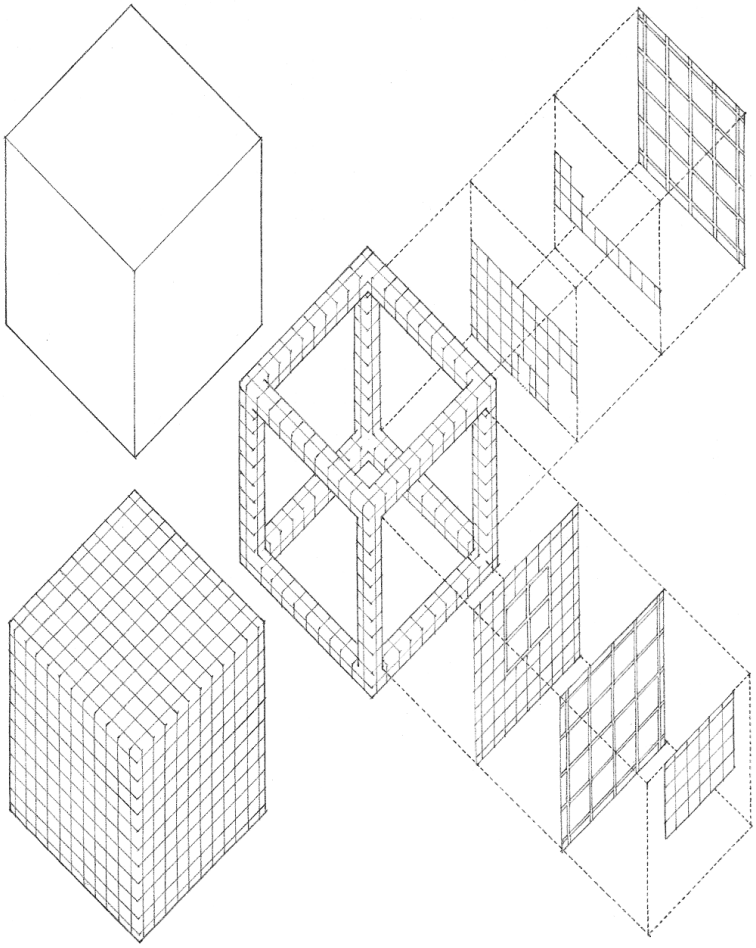
Habitat Israel, Project, Jerusalem, 1969, Moshe Safdie

Vernacular examples of clustered forms can be readily transformed into modular, geometrically ordered compositions that are related to grid organizations of form.



Habitat Montreal, 1967, Moshe Safdie

GRID FORM

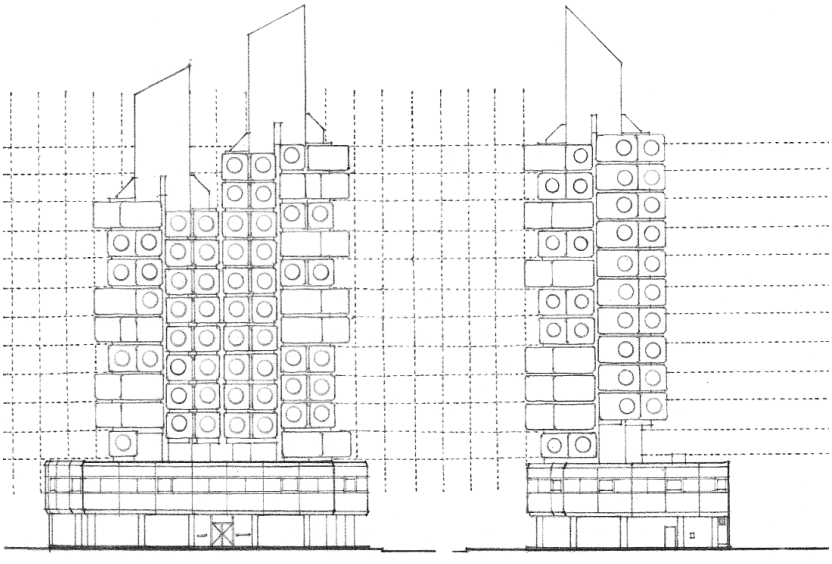


Conceptual Diagram, Museum of Modern Art, Gunma Prefecture, Japan, 1974, Arata Isozaki

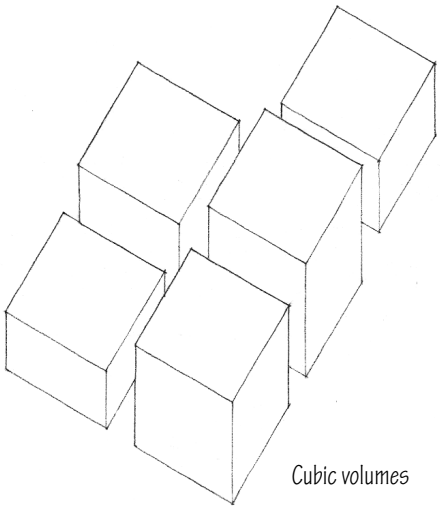
A grid is a system of two or more intersecting sets of regularly spaced parallel lines. It generates a geometric pattern of regularly spaced points at the intersections of the grid lines and regularly shaped fields defined by the grid lines themselves.

The most common grid is based on the geometry of the square. Because of the equality of its dimensions and its bilateral symmetry, a square grid is essentially nonhierarchical and bidirectional. It can be used to break down the scale of a surface into measurable units and give it an even texture. It can be used to wrap several surfaces of a form and unify them with its repetitive and pervasive geometry.

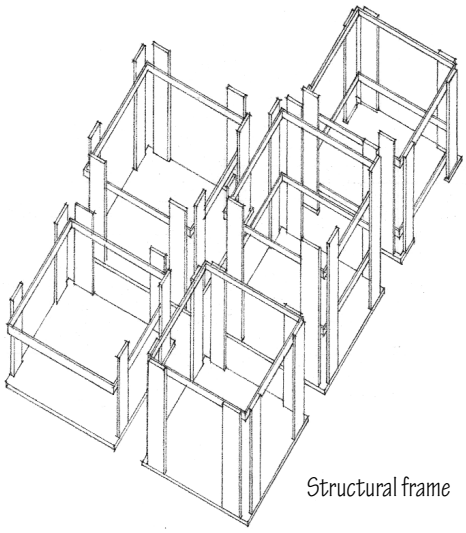
The square grid, when projected into the third dimension, generates a spatial network of reference points and lines. Within this modular framework, any number of forms and spaces can be visually organized.



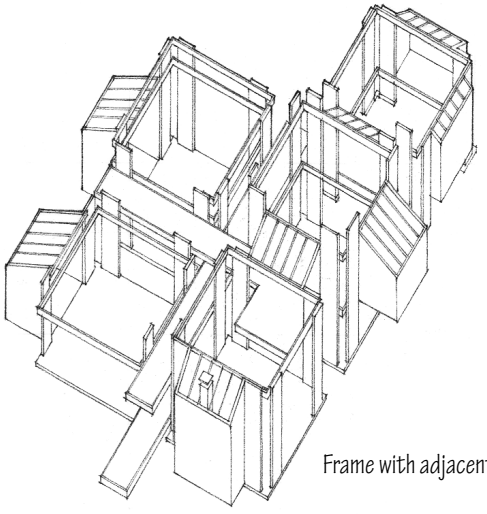
Nakagin Capsule Tower, Tokyo, 1972, Kisho Kurokawa



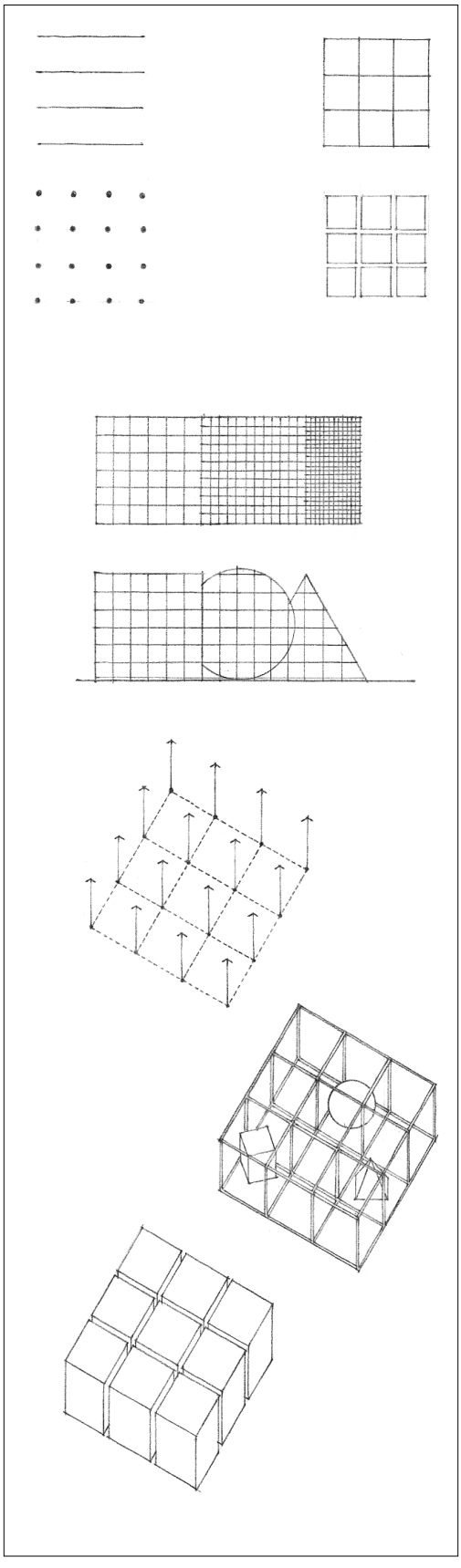
Cubic volumes



Structural frame

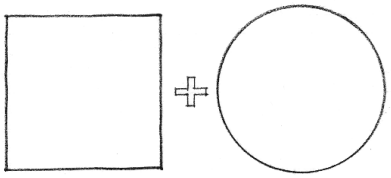


Frame with adjacent spaces

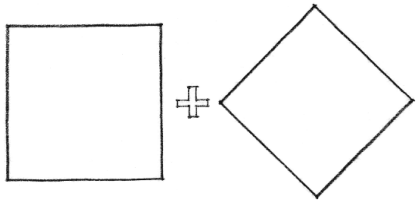


Hattenbach Residence, Santa Monica, California, 1971–1973, Raymond Kappe

FORMAL COLLISIONS OF GEOMETRY

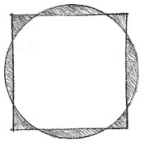


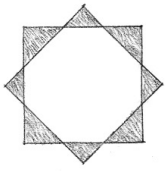
Circle and Square



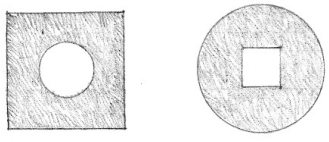
Rotated Grid

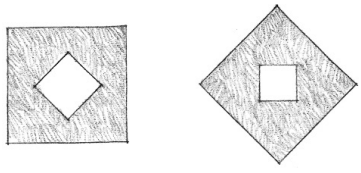
When two forms differing in geometry or orientation collide and interpenetrate each other's boundaries, each will vie for visual supremacy and dominance. In these situations, the following forms can evolve:



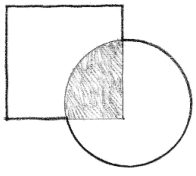


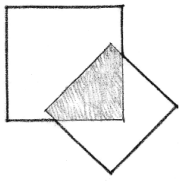
- The two forms can subvert their individual identities and merge to create a new composite form.



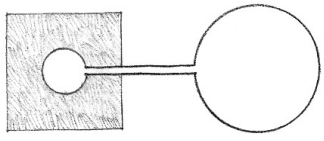


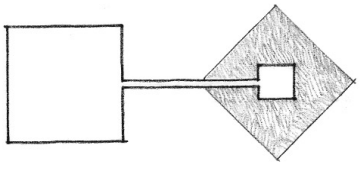
- One of the two forms can receive the other totally within its volume.



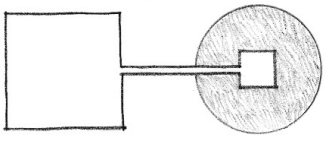


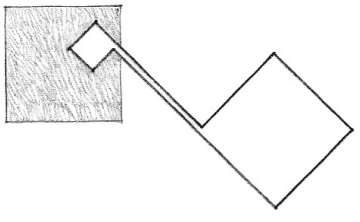
- The two forms can retain their individual identities and share the interlocking portion of their volumes.





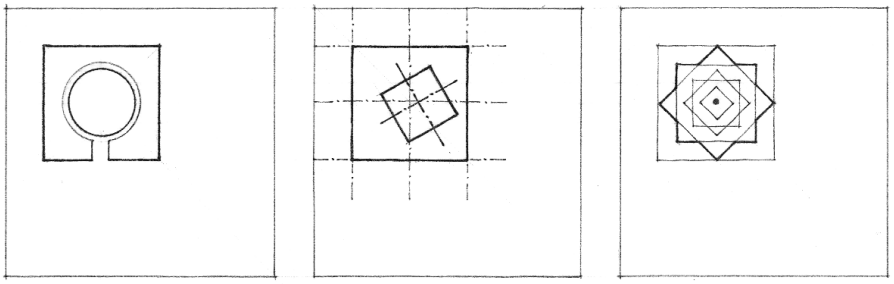
- The two forms can separate and be linked by a third element that recalls the geometry of one of the original forms.



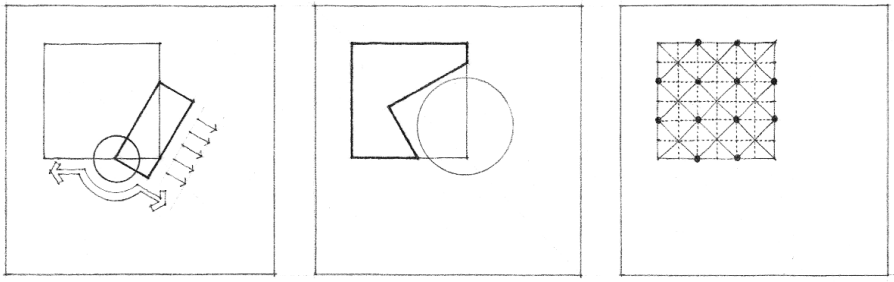


FORMAL COLLISIONS OF GEOMETRY

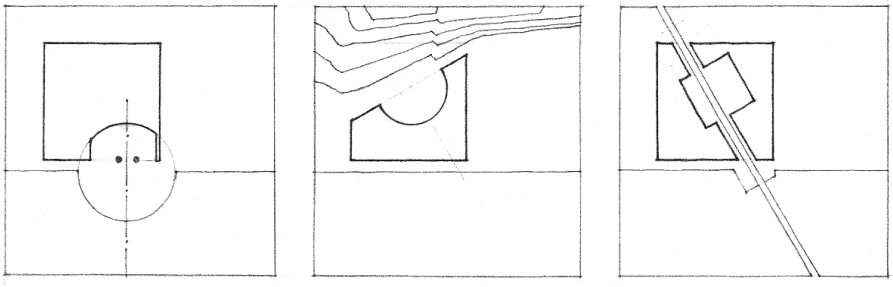
Forms differing in geometry or orientation may be incorporated into a single organization for any of the following reasons:



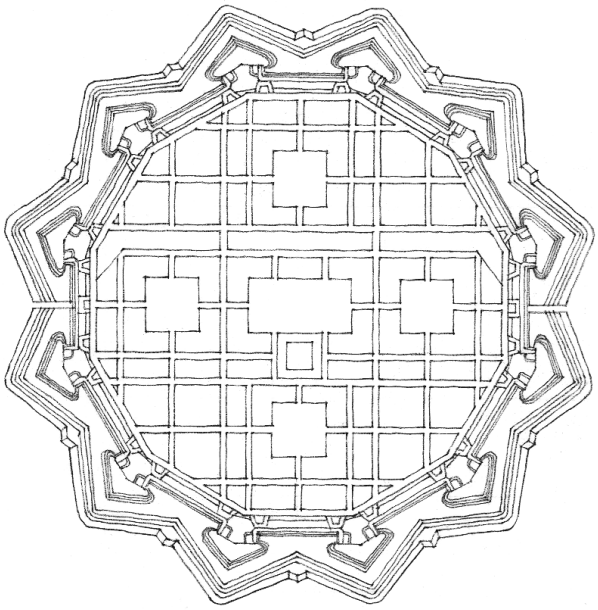
- To accommodate or accentuate the differing requirements of interior space and exterior form
- To express the functional or symbolic importance of a form or space within its context
- To generate a composite form that incorporates the contrasting geometries into its centralized organization



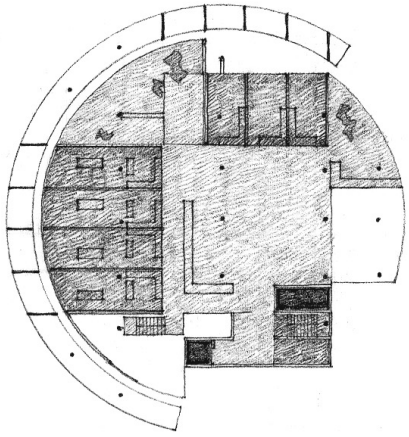
- To inflect a space toward a specific feature of a building site
- To carve a well-defined volume of space from a building form
- To express and articulate the various constructional or mechanical systems that exist within a building form

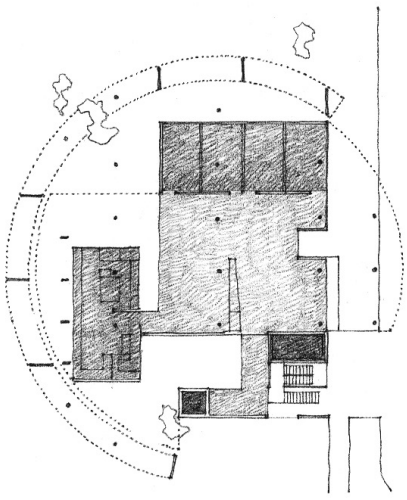


- To reinforce a local condition of symmetry in a building form
- To respond to contrasting geometries of the topography, vegetation, boundaries, or existing structures of a site
- To acknowledge an already existing path of movement through a building site



Plan for an Ideal City, 1615, Vincenzo Scamozzi

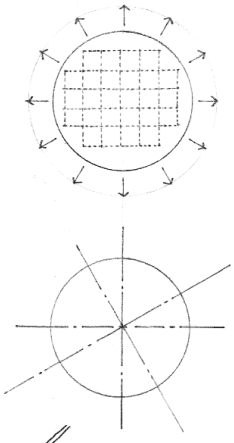


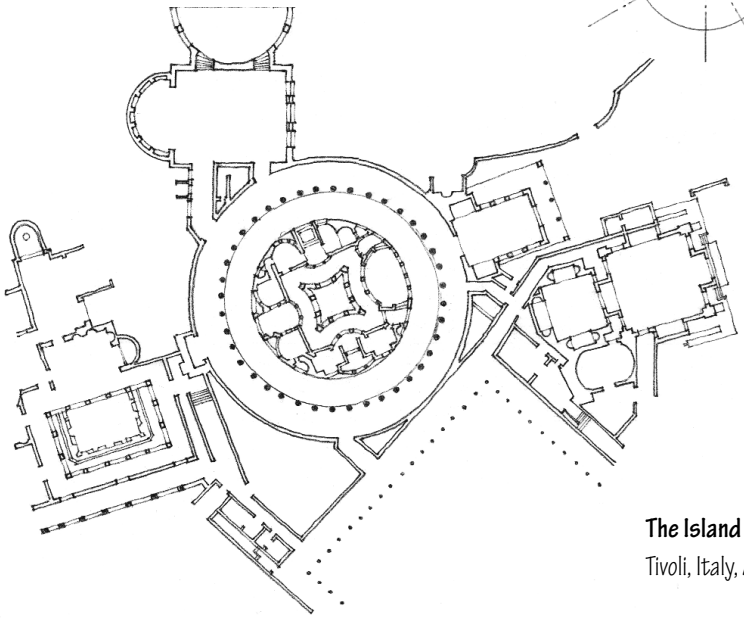


Chancellery Building, French Embassy (Project),Brasilia, 1964–1965, Le Corbusier

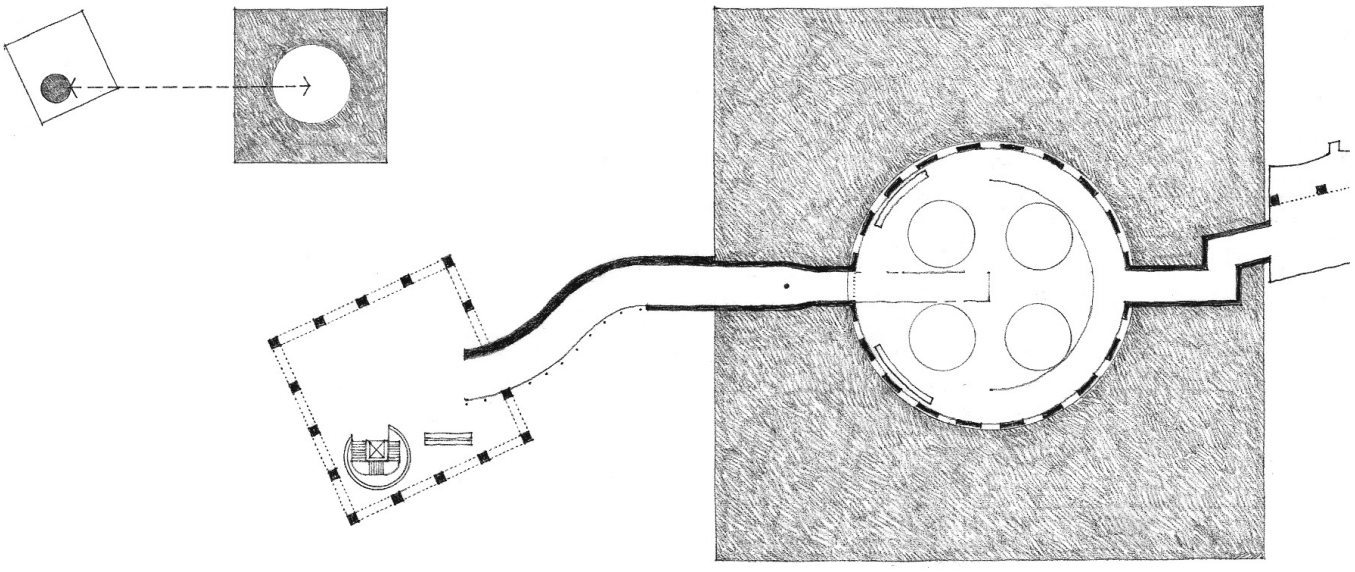
A circular form can be freestanding in its context to express its ideal shape and still incorporate a more functional, rectilinear geometry within its boundaries.

The centrality of a circular form enables it to act as a hub and unify forms of contrasting geometry or orientation about itself.

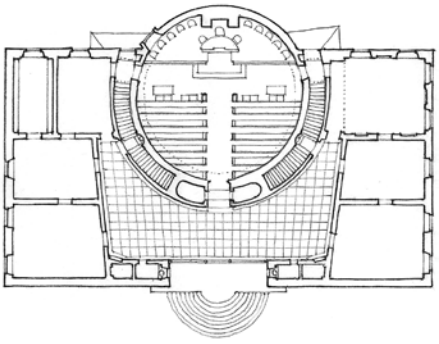




The Island Villa (Teatro Marittimo), Hadrian's Villa, Tivoli, Italy, A.D. 118–125

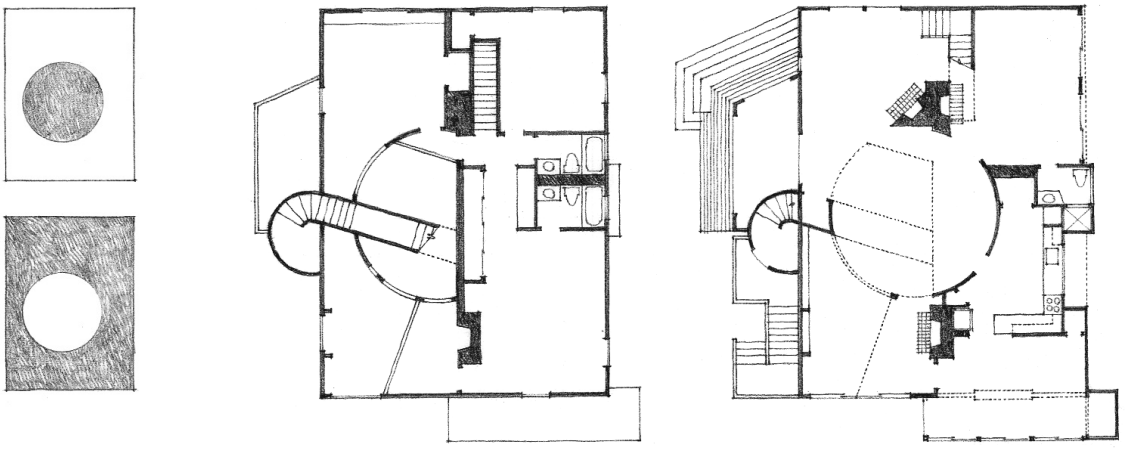


Museum for North Rhine–Westphalia (Project), Dusseldorf, Germany, 1975, James Stirling & Michael Wilford

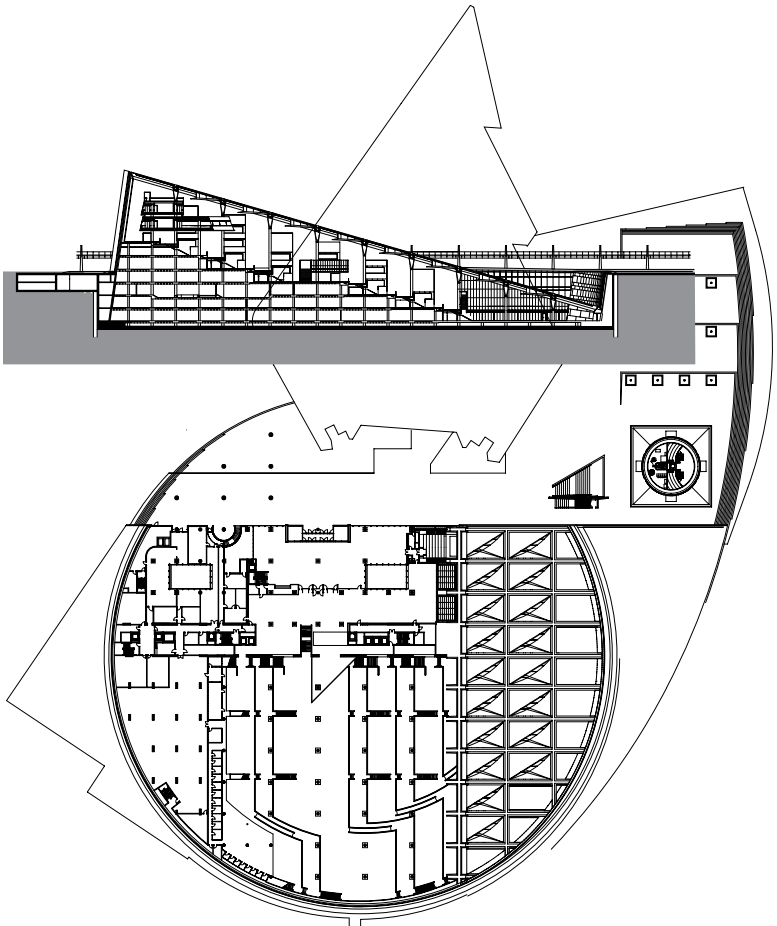


Lister County Courthouse, Solvesborg, Sweden, 1917–1921, Gunnar Asplund

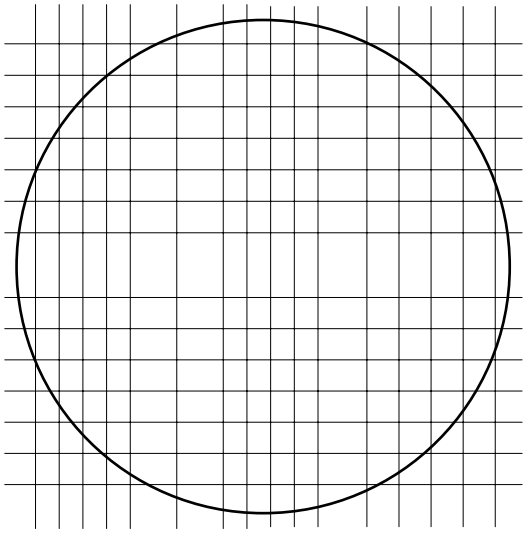
A circular or cylindrical space can serve to organize the spaces within a rectangular enclosure.

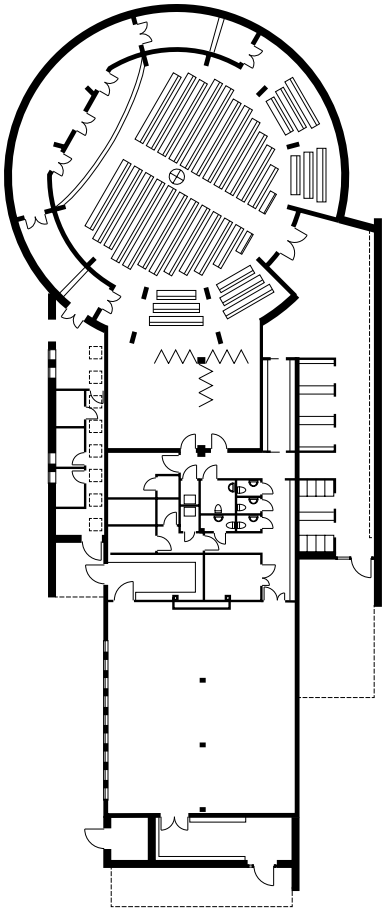


Murray House, Cambridge, Massachusetts, 1969, Charles Moore

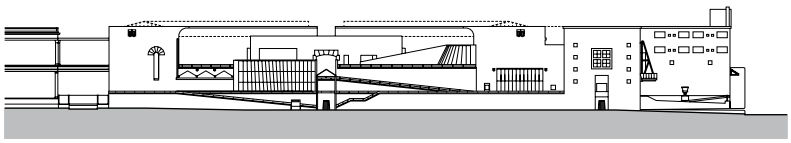


Bibliotheca Alexandrina (Alexandrian Library), Alexandria, Egypt, 1994–2002, Snøhetta in association with Christoph Kapeller and Ihab El Habbak

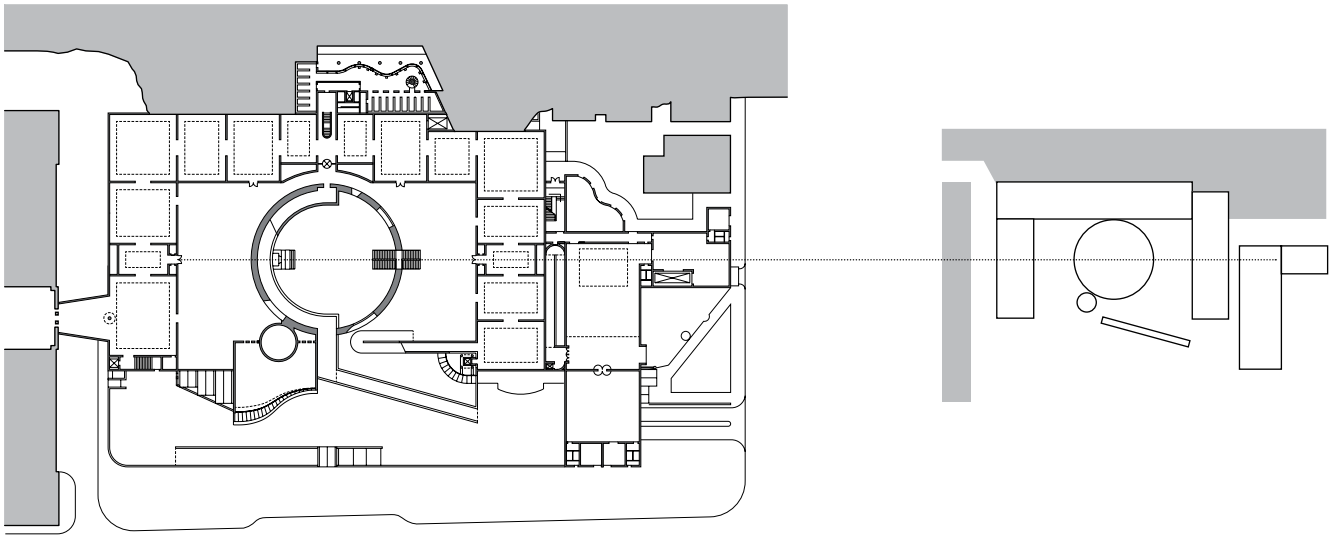




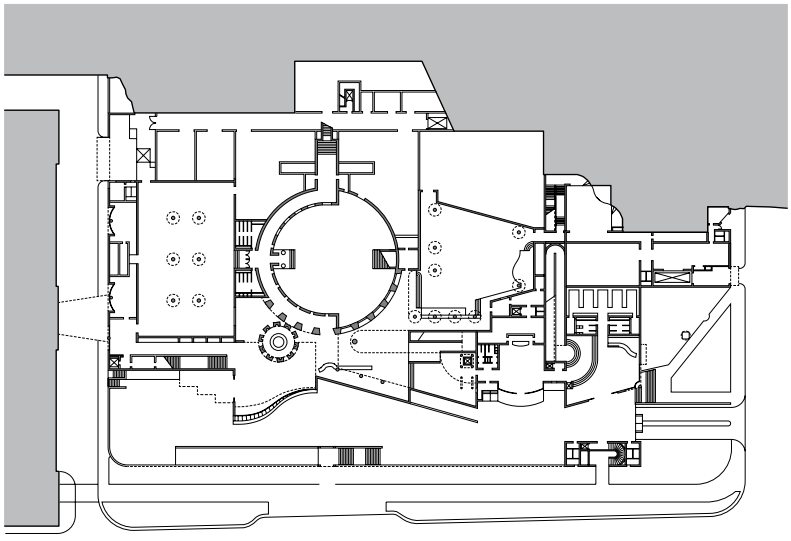
Ethiopian Orthodox Tewahedo Church (Project), Stockholm, Sweden, 2017, Belatchew Arkitekter. The existing rectilinear structure is preserved while new spaces will be added, including the circular domed volume at the end, the new church hall inspired by traditional Ethiopian church architecture.



Staatsgalerie, Stuttgart, Germany, 1979–1984, James Stirling and Michael Wilford

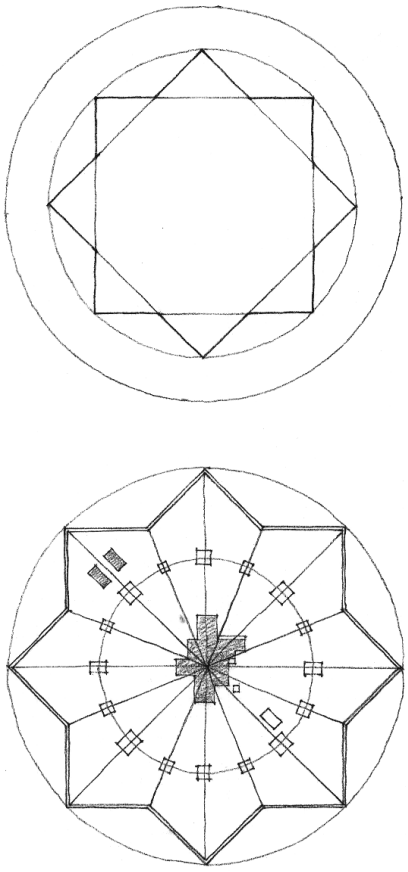


First floor plan

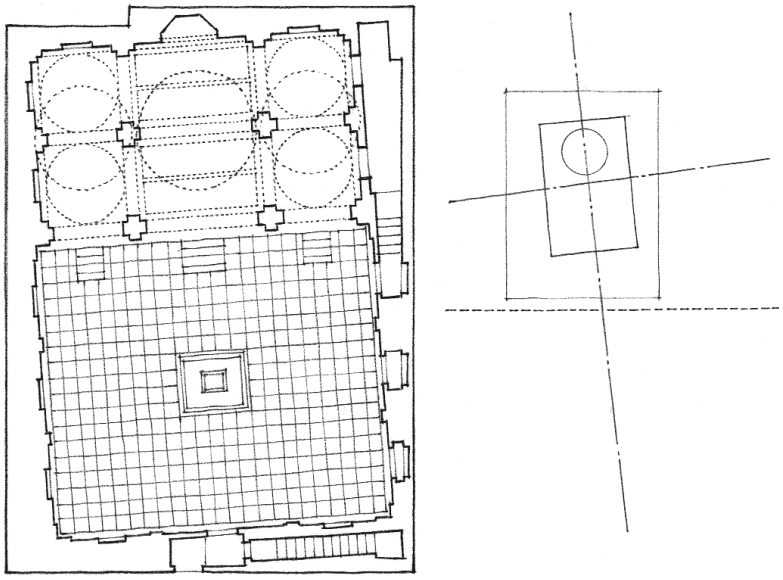


Ground floor plan

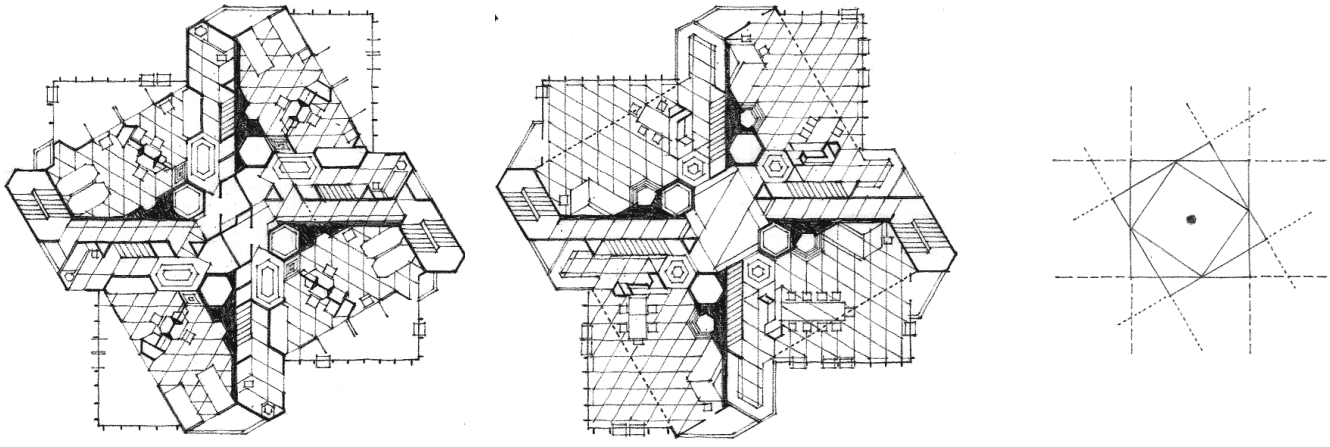
ROTATED GRID



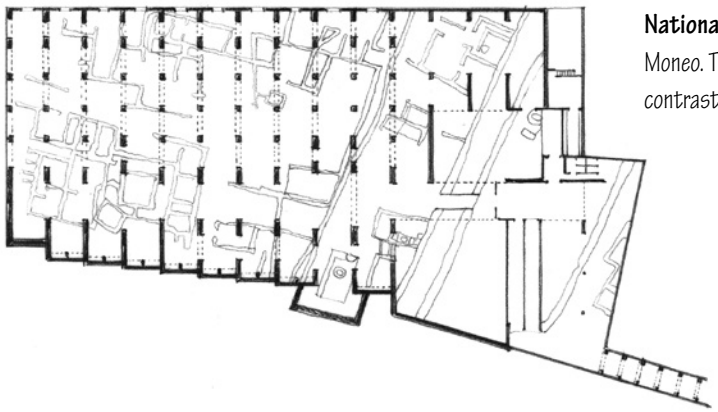
Plan of the Ideal City of Sforzinda, 1464, Antonio Filarete



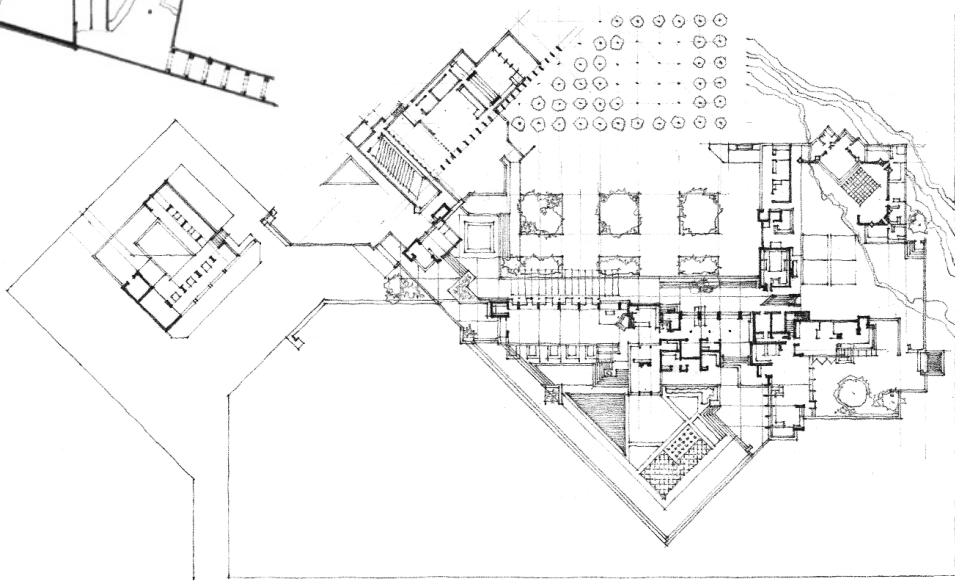
Pearl Mosque, within the Red Fort, an imperial palace at Agra, India, 1658–1707. The interior space of this mosque is oriented exactly with the cardinal points so that the quibla wall faces in the direction of the holy city of Mecca, while its exterior conforms to the existing layout of the fort.



St. Mark's Tower, Project, New York City, 1929, Frank Lloyd Wright

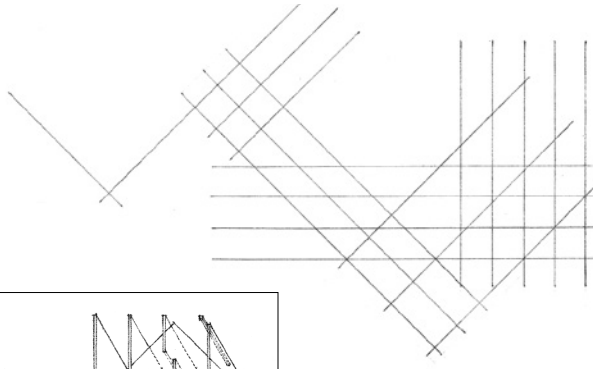


National Museum of Roman Art, Mérida, Spain, 1980–1986, Rafael Moneo. The structural grid of the lower level of the museum floats over and contrasts with the geometry of the ancient Roman remains of Mérida.



A Diagram of Architecture:

Taliesin West, near Scottsdale, Arizona, 1938–1959, Frank Lloyd Wright



A diagram by Bernhard Hoesli of the geometry regulating the layout of Taliesin West

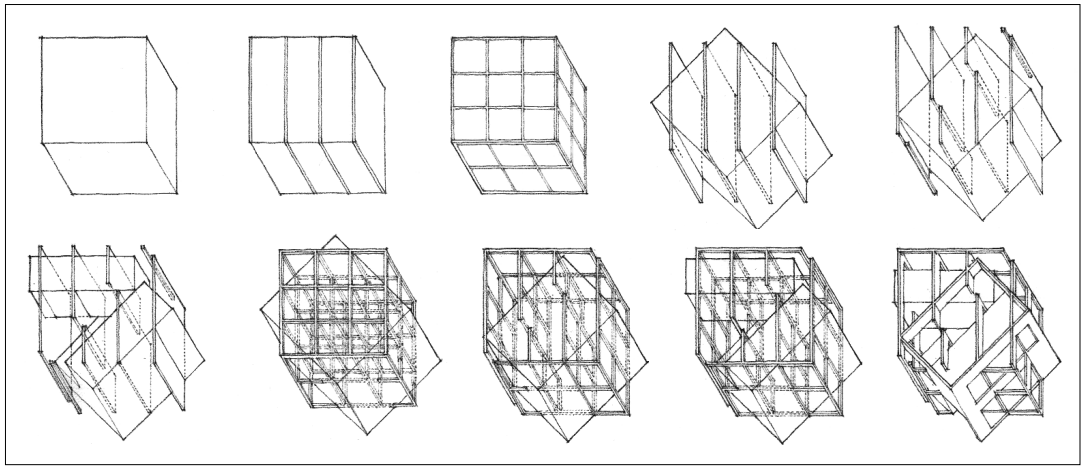
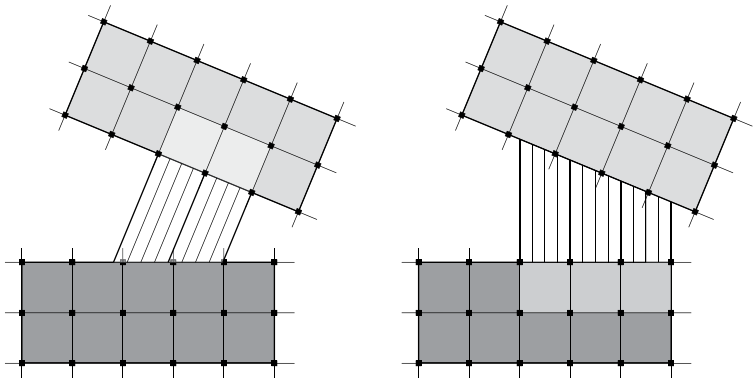


Diagram as Architecture:

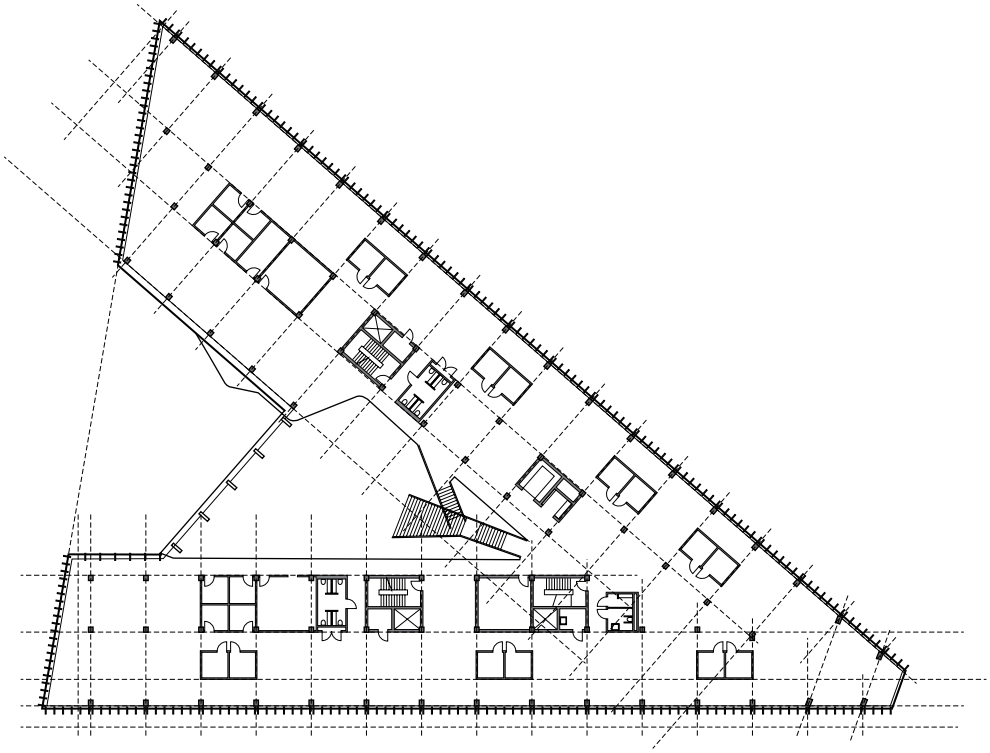
House III for Robert Miller, Lakeville, Connecticut, 1971, Design Development Drawings, Peter Eisenman

ROTATED GRID



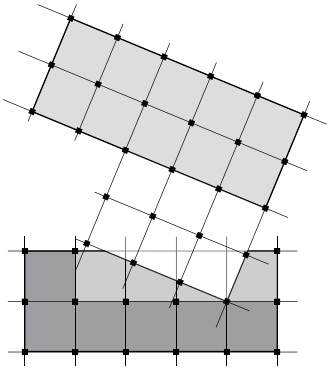
The transitional link between two geometric orientations may reflect either one of the orientations or neither of them. If the linking space conforms to one of the orientations, the contrasting orientation will tend to be emphasized.

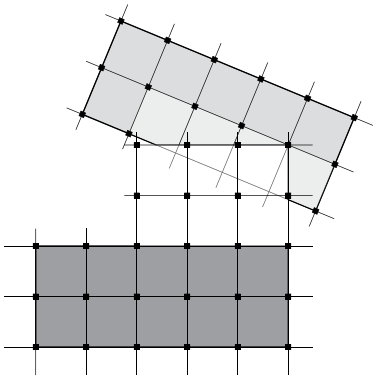
- Contrasting orientations can lead to the linking space having unique spanning conditions.

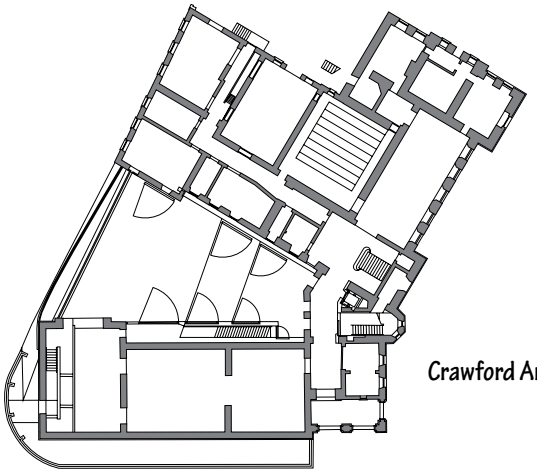


Bjergsted Financial Park, Bjergsted, Norway, 2018, Helen & Hard Architects with SAAHA Architects

When two grids of contrasting orientation overlap, one will tend to dominate the other. The ascendency of one grid can be further emphasized by a change in vertical scale. Strong structural and architectural emphasis is placed on the exceptional spaces where one can experience both geometries.

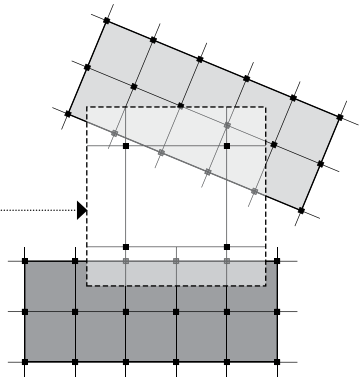


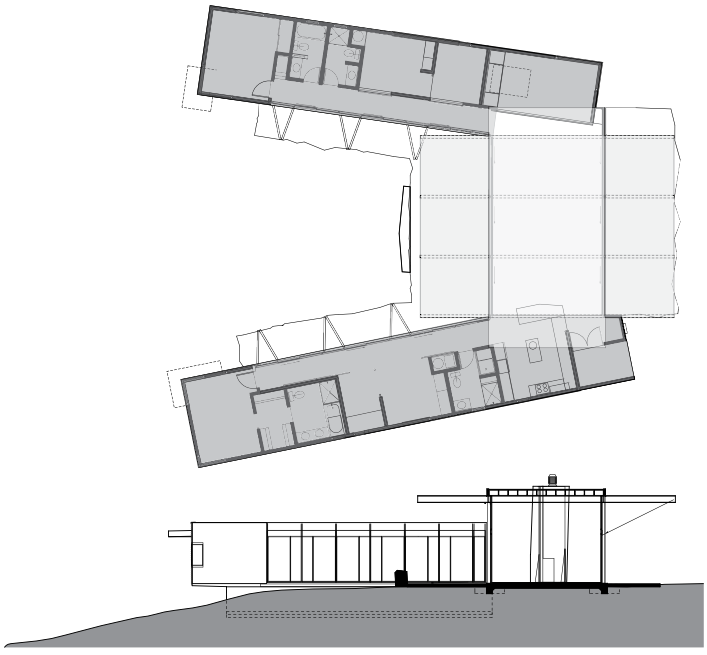




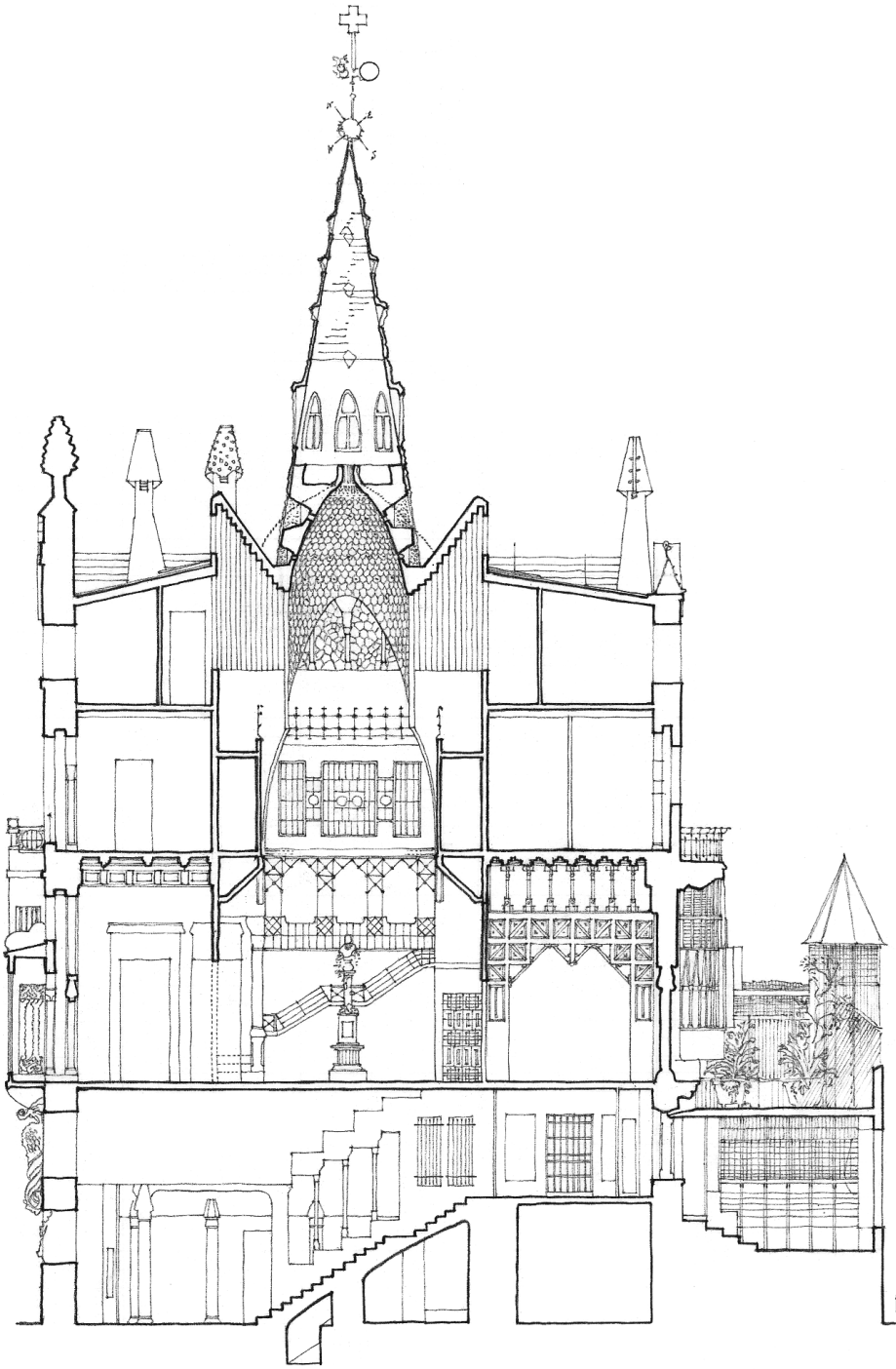
Crawford Art Gallery, Cork, Ireland, 2000, Erick van Egeraat Associated Architects

Another way of treating differing orientations is to unify both parts by gathering them under a third dominant structural form. Like the two previous examples, emphasis occurs at the exceptional condition where two different structural systems are juxtaposed.

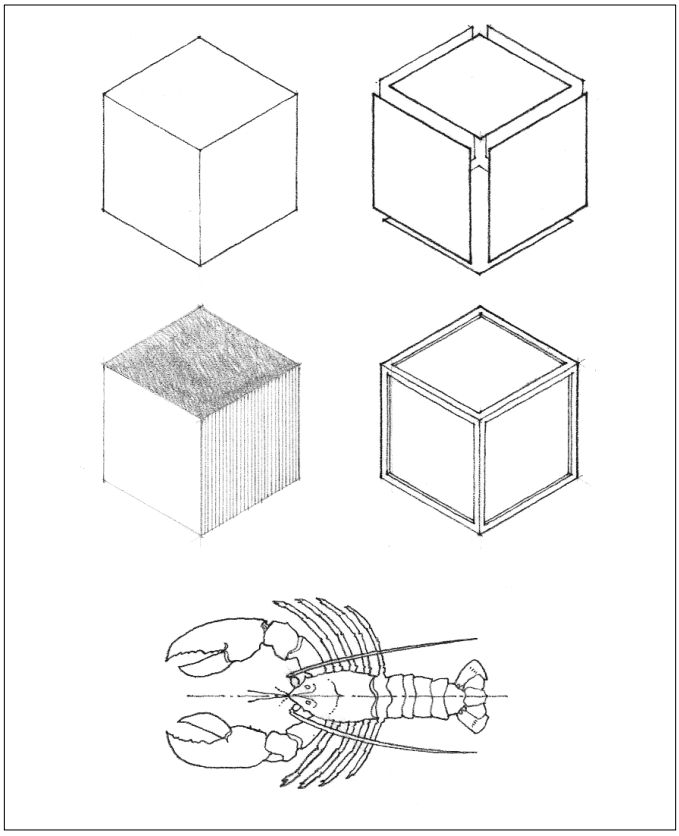


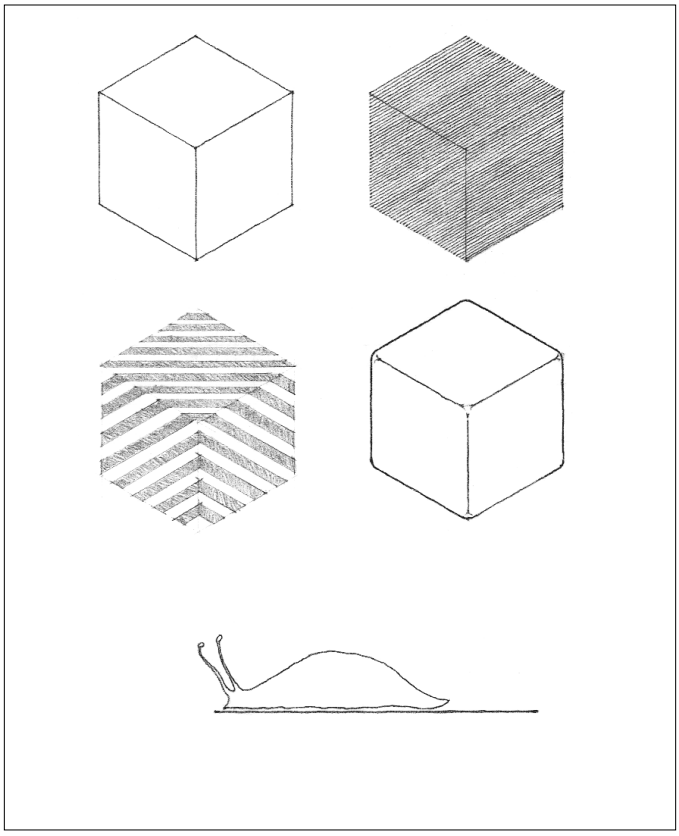


Valley Center House, San Diego, California, 1999, Daly, Genik Architects



Palacio Güell, Barcelona, 1885–1889, Antonio Gaudi





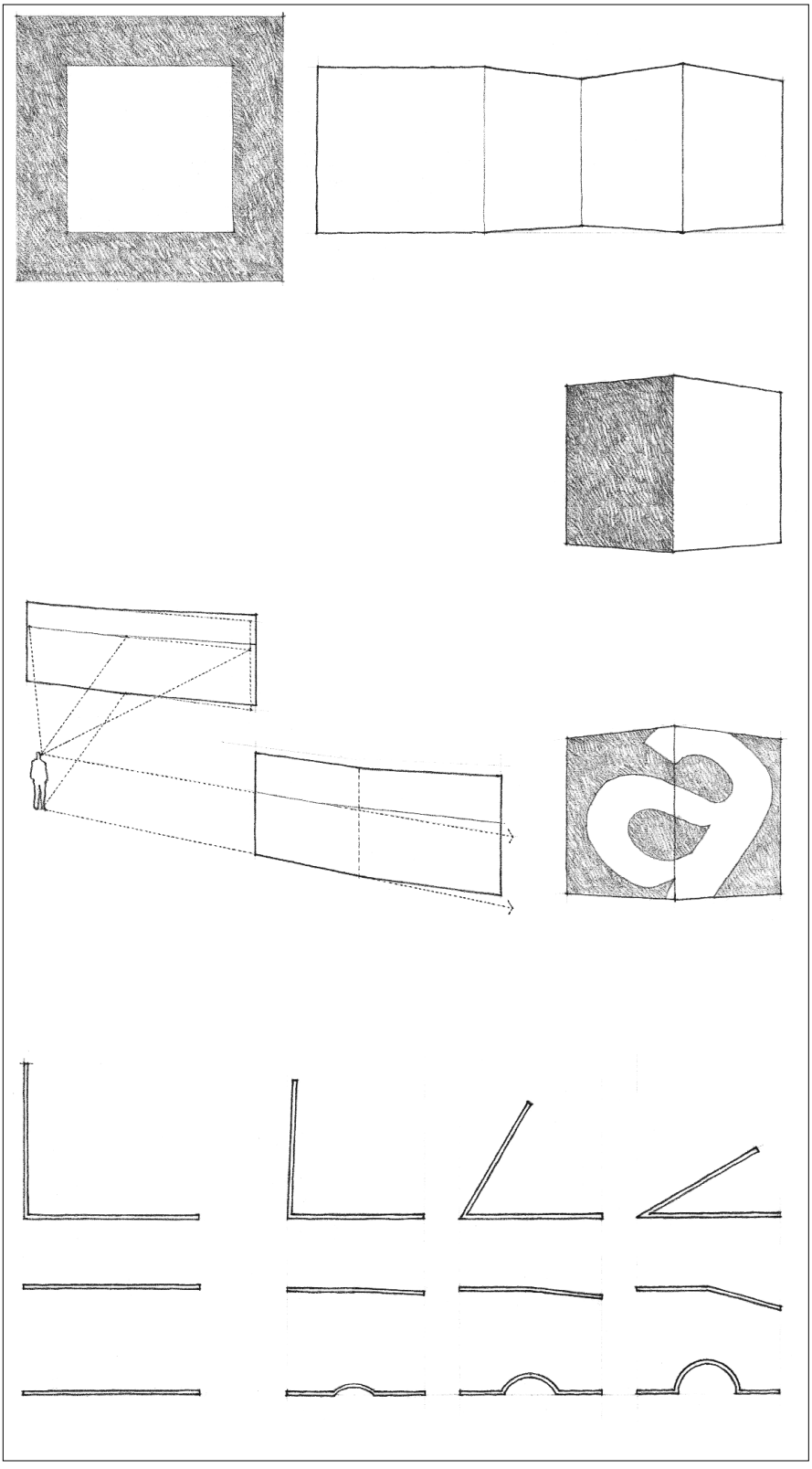
Articulation refers to the manner in which the surfaces of a form come together to define its shape and volume. An articulated form clearly reveals the precise nature of its parts and their relationships to each other and to the whole. Its surfaces appear as discrete planes with distinct shapes and their overall configuration is legible and easily perceived. In a similar manner, an articulated group of forms accentuates the joints between the constituent parts in order to visually express their individuality.

A form can be articulated by:

- Differentiating adjoining planes with a change in material, color, texture, or pattern
- Developing corners as distinct linear elements independent of the abutting planes
- Removing corners to physically separate neighboring planes
- Illuminating the form to create sharp contrasts in tonal value along edges and corners

In opposition to the emphasis on joints and joinery, the corners of a form can be rounded and smoothed over to emphasize the continuity of its surfaces. Or a material, color, texture, or pattern can be carried across a corner onto the adjoining surfaces to de-emphasize the individuality of the surface planes and emphasize instead the volume of a form.

EDGES & CORNERS



Since the articulation of a form depends to a great degree on how its surfaces meet each other at corners, how these edge conditions are resolved is critical to the definition and clarity of a form.

While a corner can be articulated by simply contrasting the surface qualities of the adjoining planes, or obscured by layering their joining with an optical pattern, our perception of its existence is also affected by the laws of perspective and the quality of light that illuminates the form.

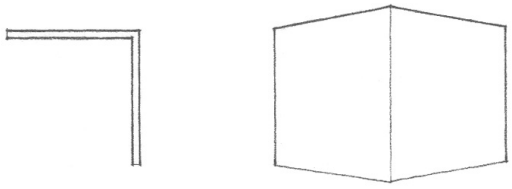
For a corner to be formally active, there must be more than a slight deviation in the angle between the adjoining planes. Since we constantly search for regularity and continuity within our field of vision, we tend to regularize or smooth out slight irregularities in the forms we see. For example, a wall plane that is bent only slightly will appear to be a single flat plane, perhaps with a surface imperfection. A corner would not be perceived.

At what point do these formal deviations become an acute angle? . . . a right angle?

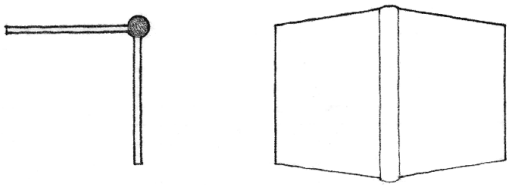
a segmented line? . . . a straight line?

a circular segment? . . . a change in a line's contour?

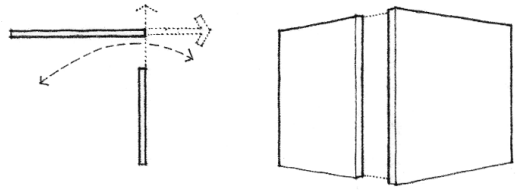
Corners define the meeting of two planes. If the two planes simply touch and the corner remains unadorned, the presence of the corner will depend on the visual treatment of the adjoining surfaces. This corner condition emphasizes the volume of a form.



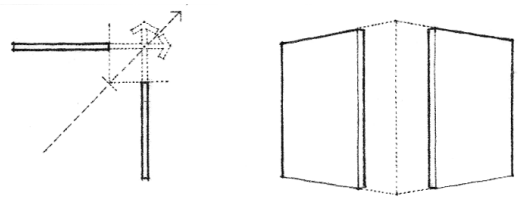
A corner condition can be visually reinforced by introducing a separate and distinct element that is independent of the surfaces it joins. This element articulates the corner as a linear condition, defines the edges of the adjoining planes, and becomes a positive feature of the form.



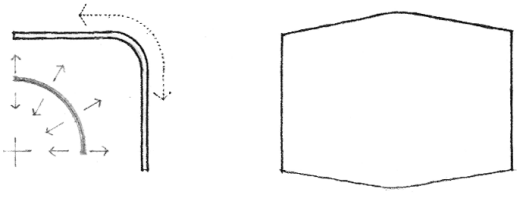
If an opening is introduced to one side of the corner, one of the planes will appear to bypass the other. The opening diminishes the corner condition, weakens the definition of the volume within the form, and emphasizes the planar qualities of the neighboring surfaces.



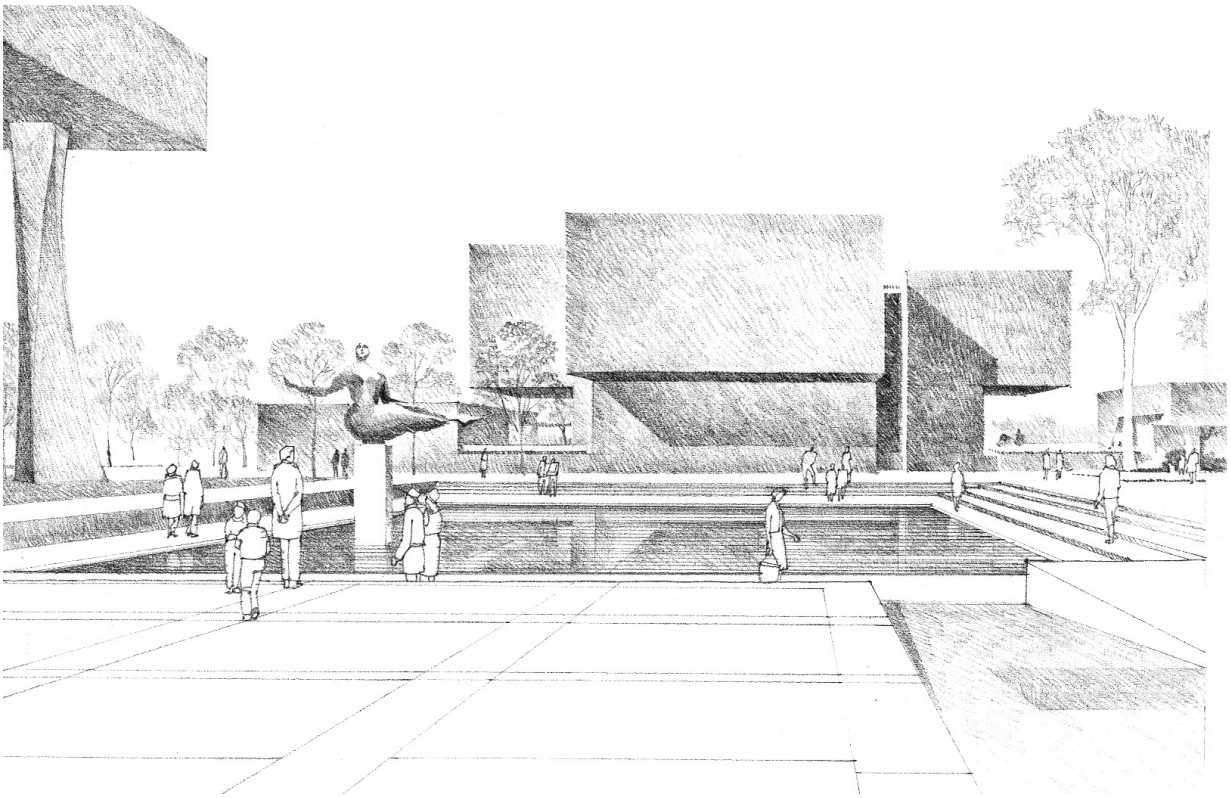
If neither plane is extended to define the corner, a volume of space is created to replace the corner. This corner condition deteriorates the volume of the form, allows the interior space to leak outward, and clearly reveals the surfaces as planes in space.



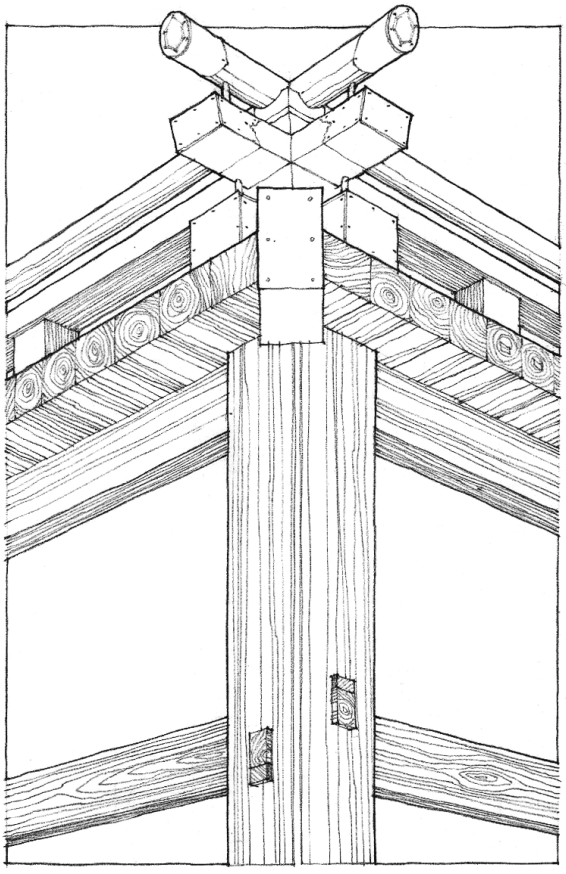
Rounding off the corner emphasizes the continuity of the bounding surfaces of a form, the compactness of its volume, and softness of its contour. The scale of the radius of curvature is important. If too small, it becomes visually insignificant; if too large, it affects the interior space it encloses and the exterior form it describes.



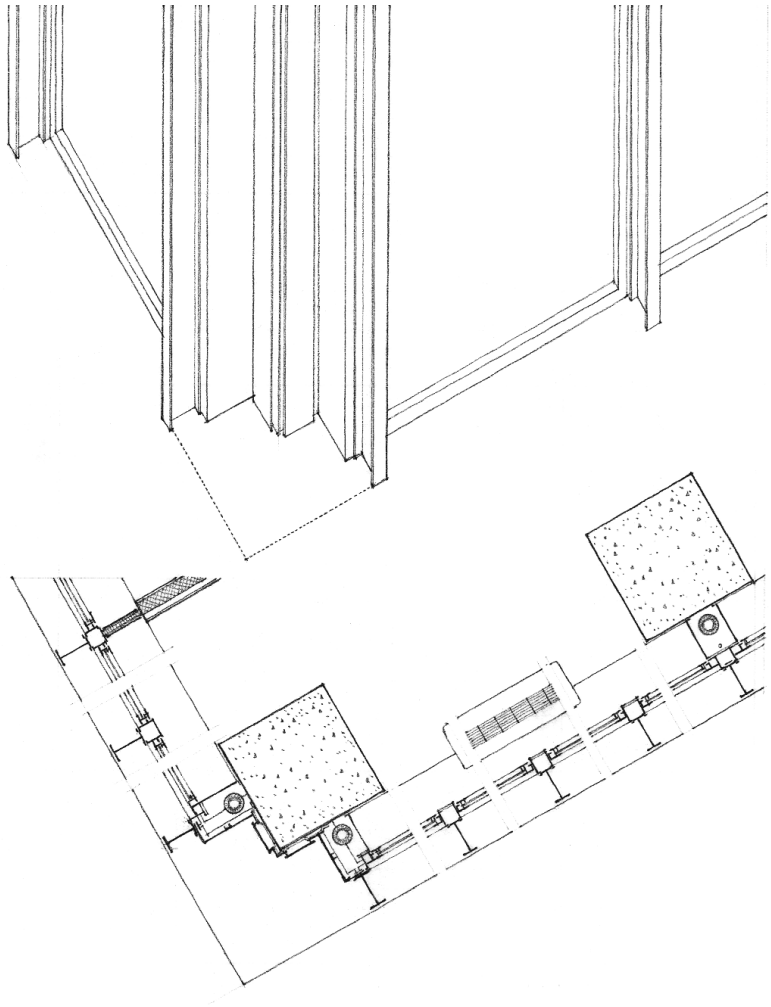
CORNERS



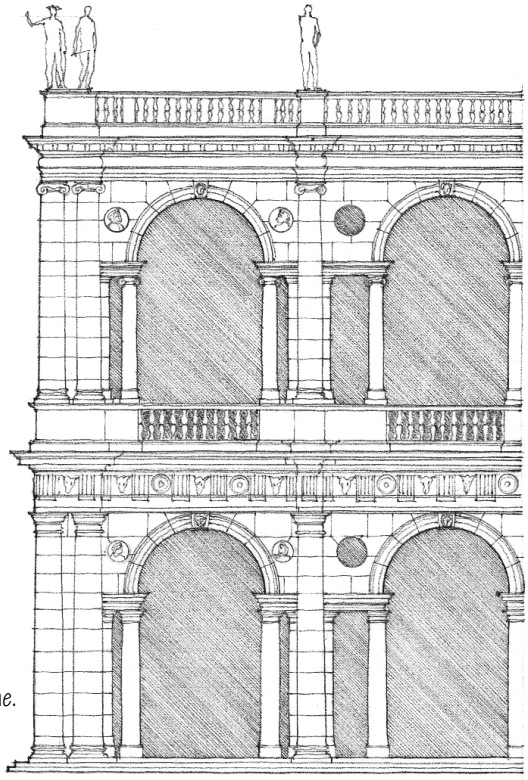
Everson Museum, Syracuse, New York, 1968, I.M. Pei.
The unadorned corners of the forms emphasize the volume of their mass.

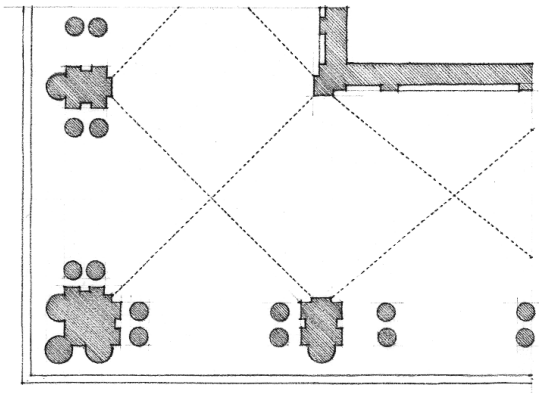


Corner Detail, **Izumo Shrine**, Shimane Prefecture, Japan, A.D. 717 (last rebuilt in 1744).
The timber joinery articulates the individuality of the members meeting at the corner.



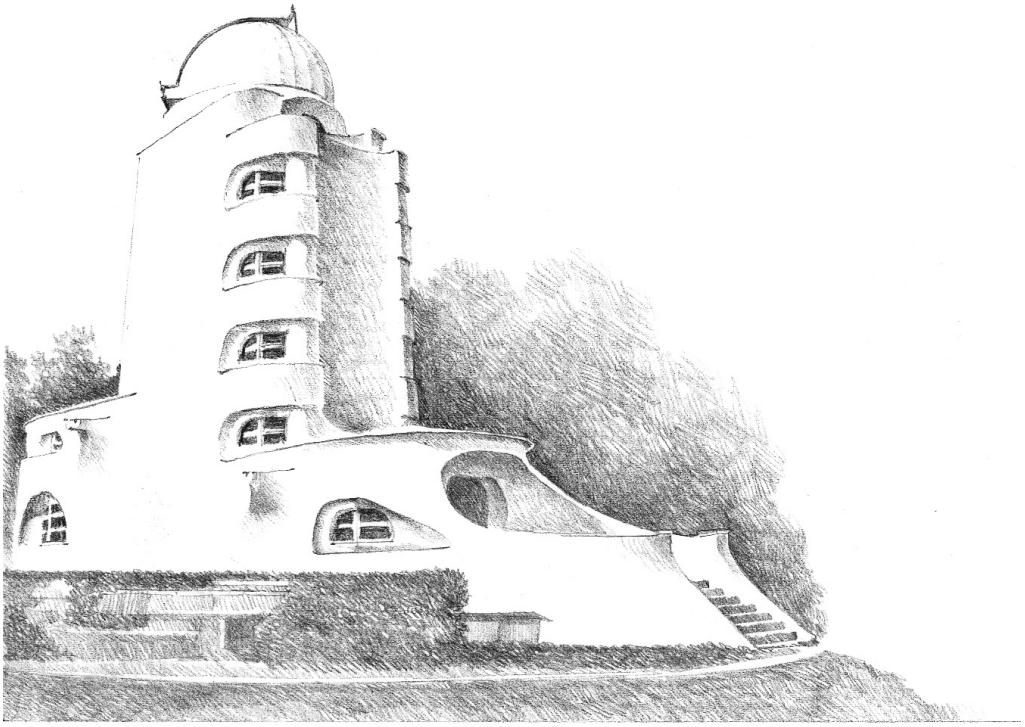
Corner Detail, **Commonwealth Promenade Apartments**, Chicago, 1953–1956, Mies van der Rohe. The corner member is recessed to be independent of the adjoining wall planes.



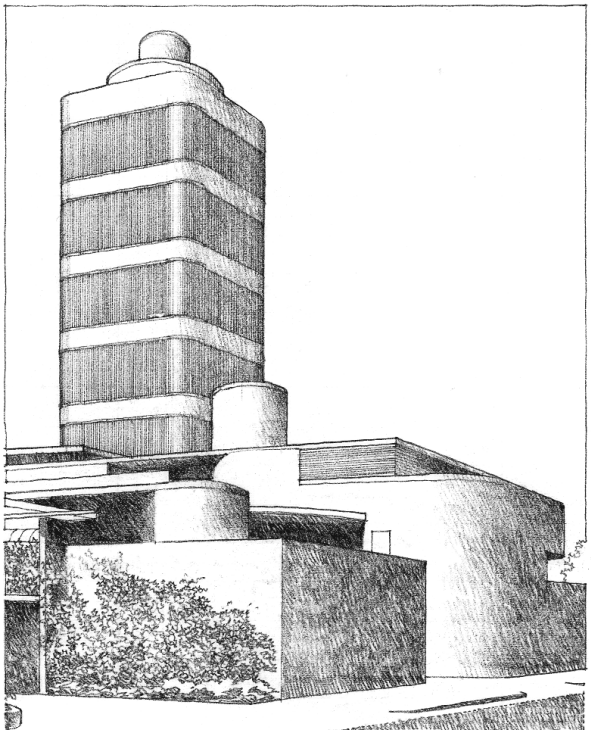


Corner Detail, **The Basilica**, Vicenza, Italy, 1545, Andrea Palladio. The corner column emphasizes the edge of the building form.

CORNERS

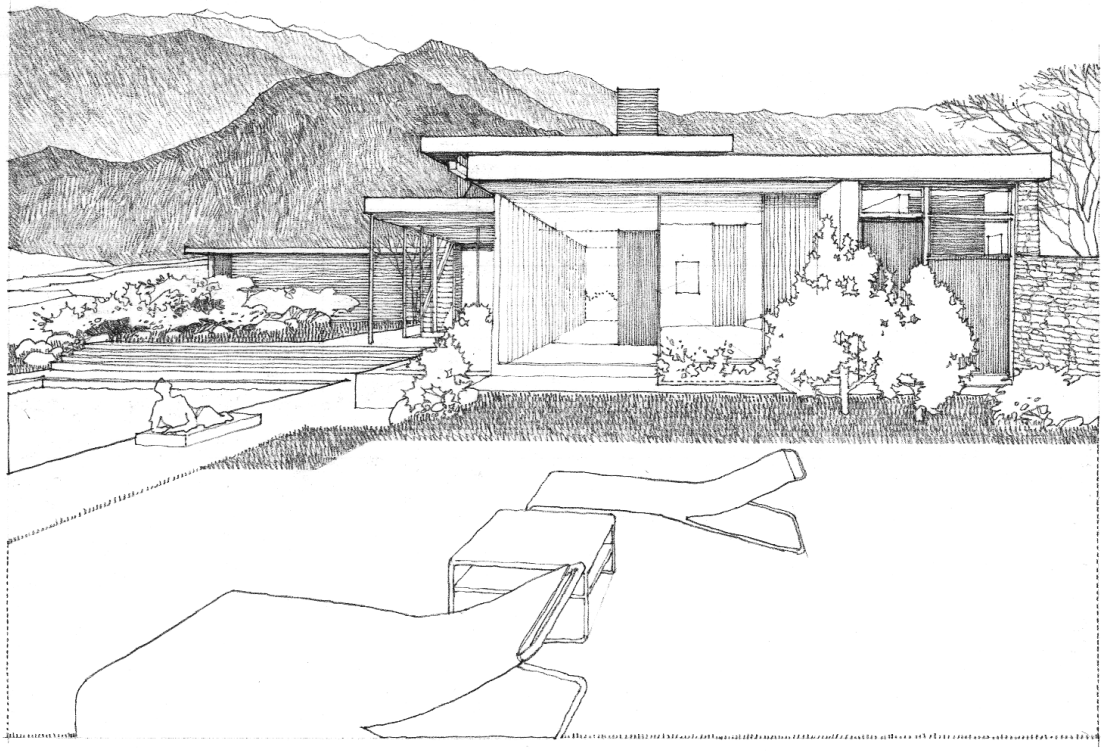


Einstein Tower, Potsdam, Germany, 1919, Eric Mendelsohn



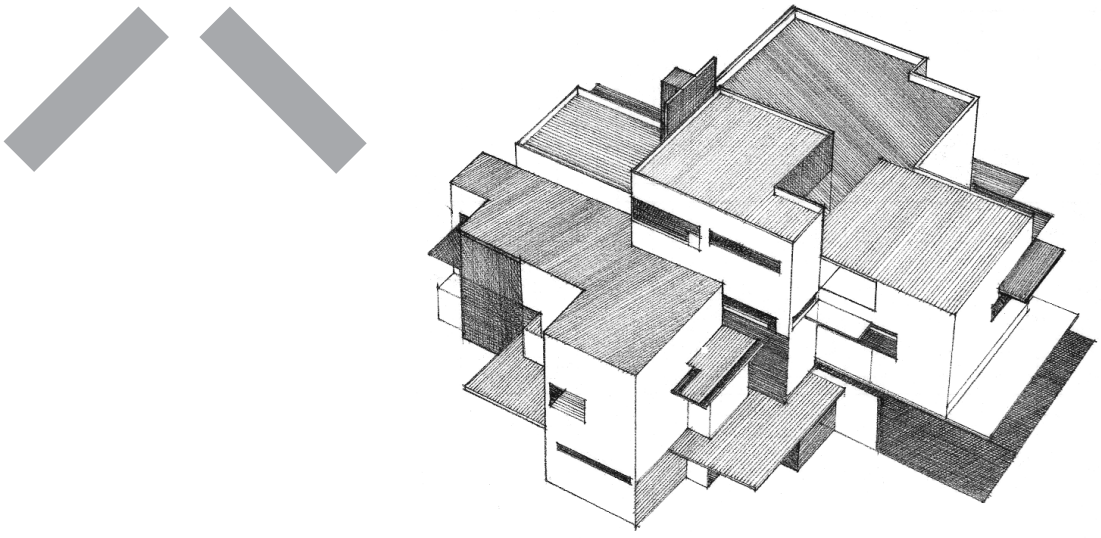
Rounded corners express continuity of surface, compactness of volume, and softness of form.

Laboratory Tower, Johnson Wax Building, Racine, Wisconsin, 1950, Frank Lloyd Wright



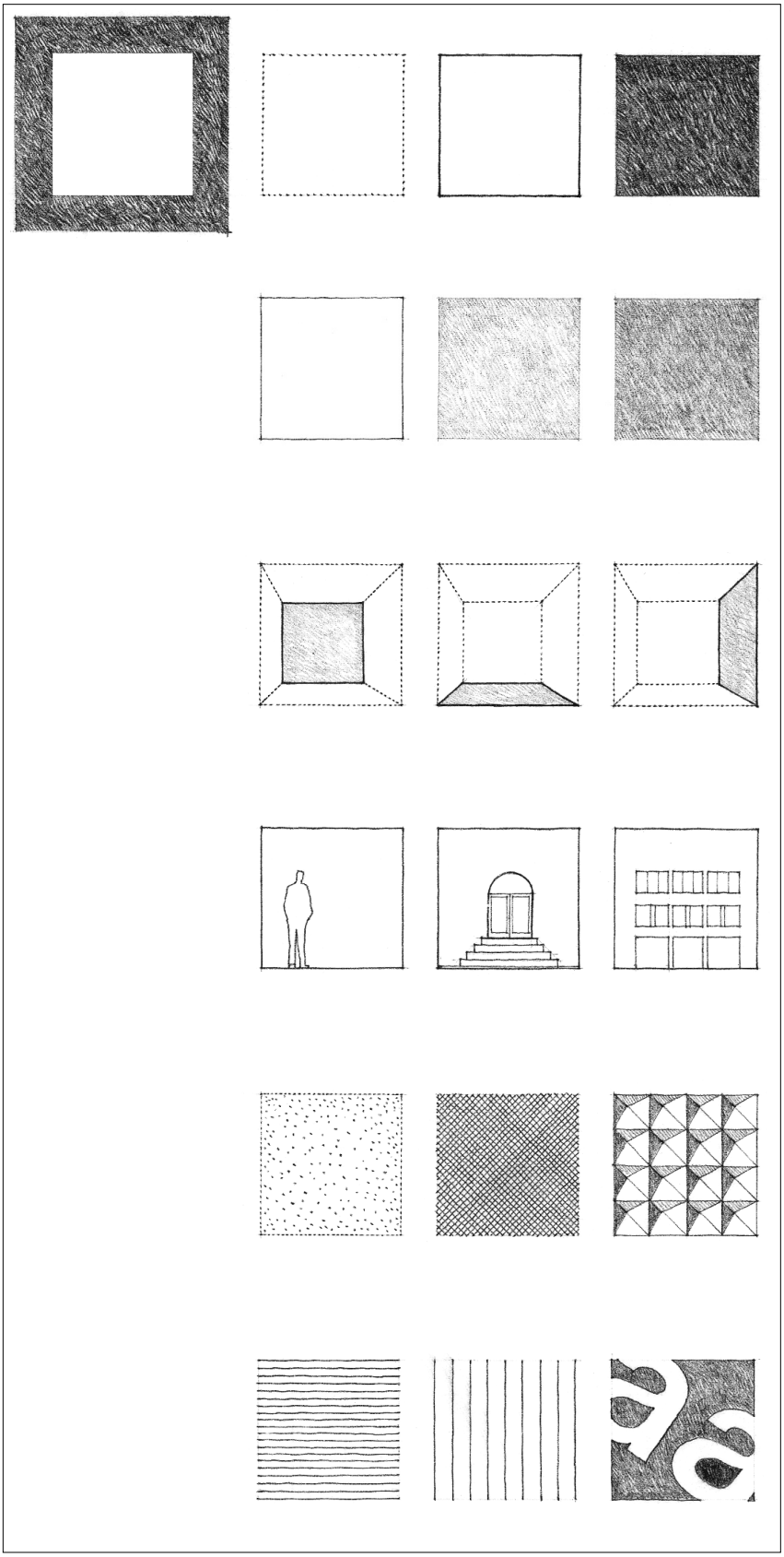
Kaufmann Desert House, Palm Springs, California, 1946, Richard Neutra

Openings at corners emphasize the definition of planes over volume.



Architectural Design Study, 1923, Van Doesburg and Van Esteren

SURFACE ARTICULATION



Our perception of the shape, size, scale, proportion, and visual weight of a plane is influenced by its surface properties as well as its visual context.

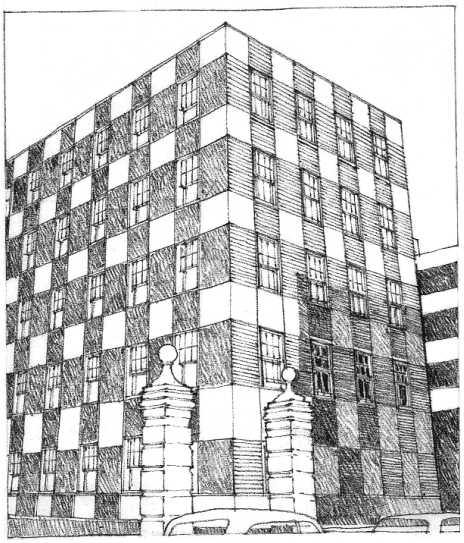
- A distinct contrast between the surface color of a plane and that of the surrounding field can clarify its shape, while modifying its tonal value can either increase or decrease its visual weight.

- A frontal view reveals the true shape of a plane; oblique views distort it.

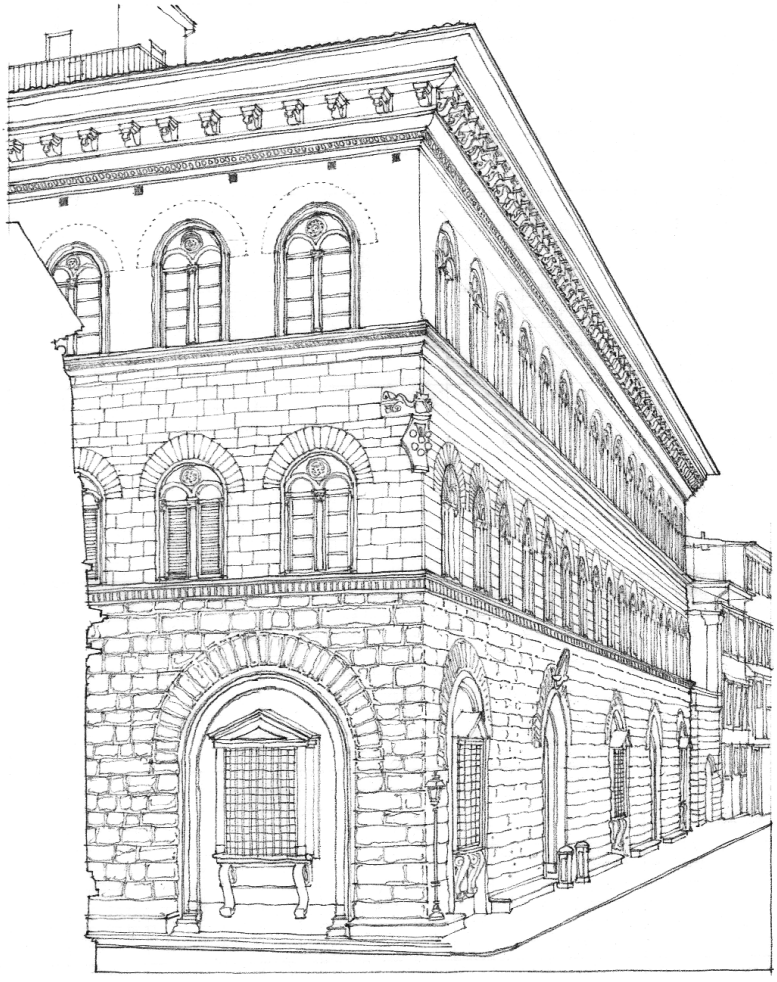
- Elements of known size within the visual context of a plane can aid our perception of its size and scale.

- Texture and color together affect the visual weight and scale of a plane and the degree to which it absorbs or reflects light and sound.

- Directional or oversized optical patterns can distort the shape or exaggerate the proportions of a plane.

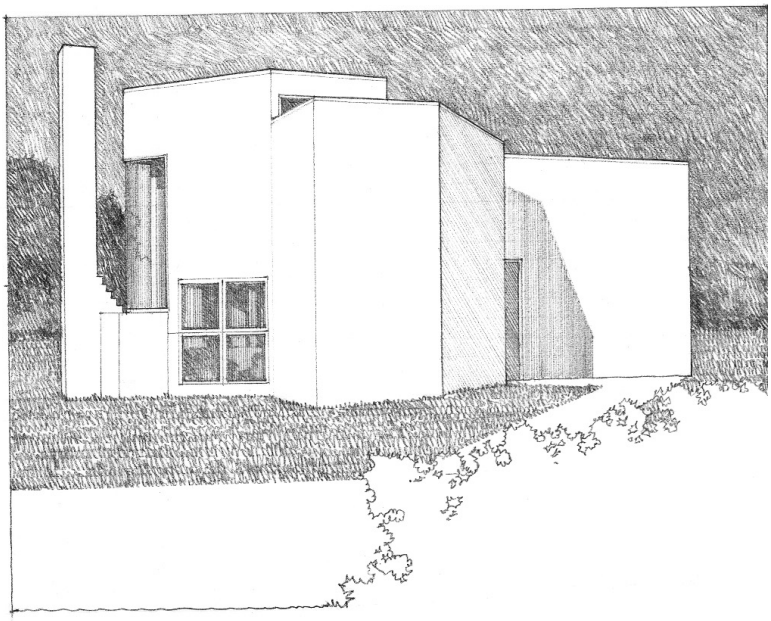


Vincent Street Flats, London, 1928, Sir Edwin Lutyens



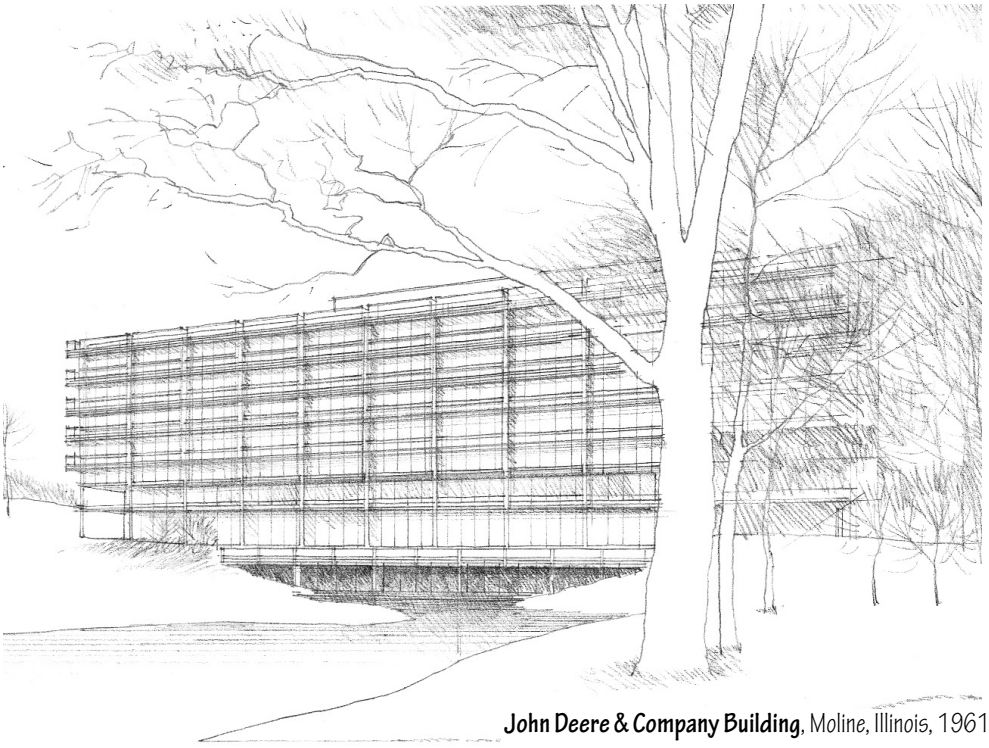
Palazzo Medici-Ricardo, Florence, Italy, 1444–1460, Michelozzi

The color, texture, and pattern of surfaces articulate the existence of planes and influence the visual weight of a form.

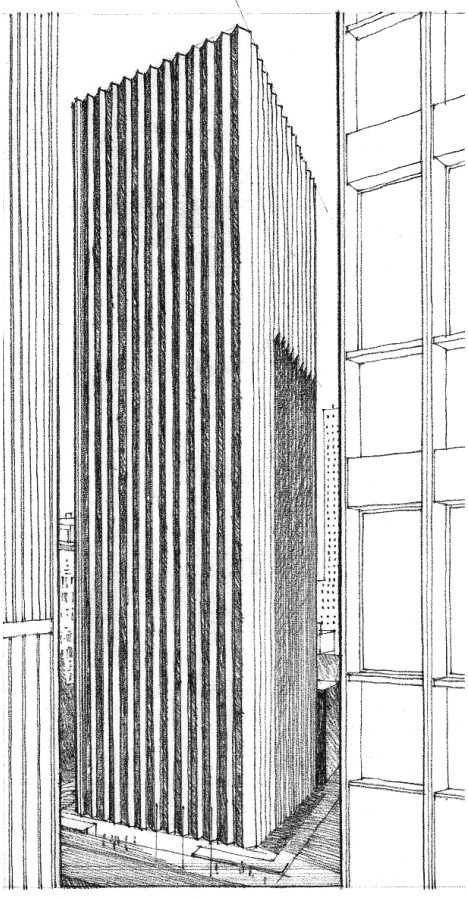


Hoffman House, East Hampton, New York, 1966–1967, Richard Meier

SURFACE ARTICULATION

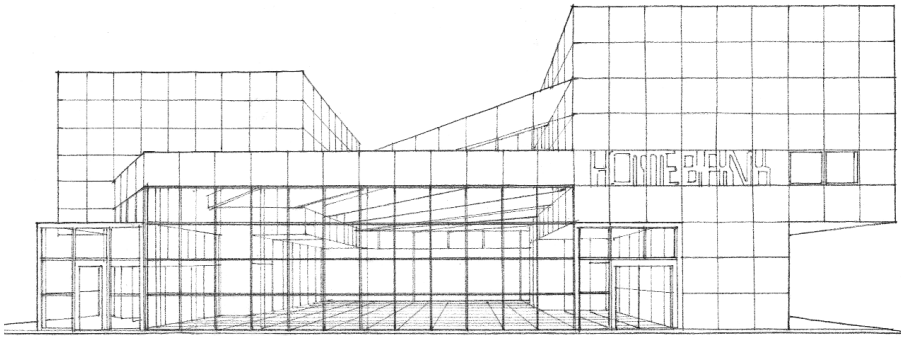


John Deere & Company Building, Moline, Illinois, 1961–1964, Eero Saarinen & Associates.
The linear sun-shading devices accentuate the horizontality of the building form.

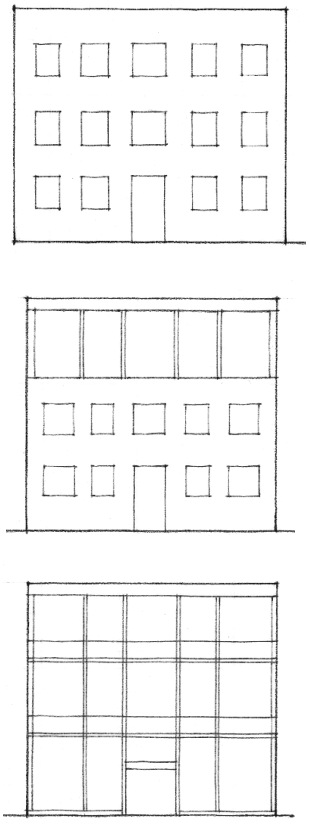


CBS Building, New York City, 1962–1964, Eero Saarinen & Associates.
Linear columnar elements emphasize the verticality of this high-rise structure.

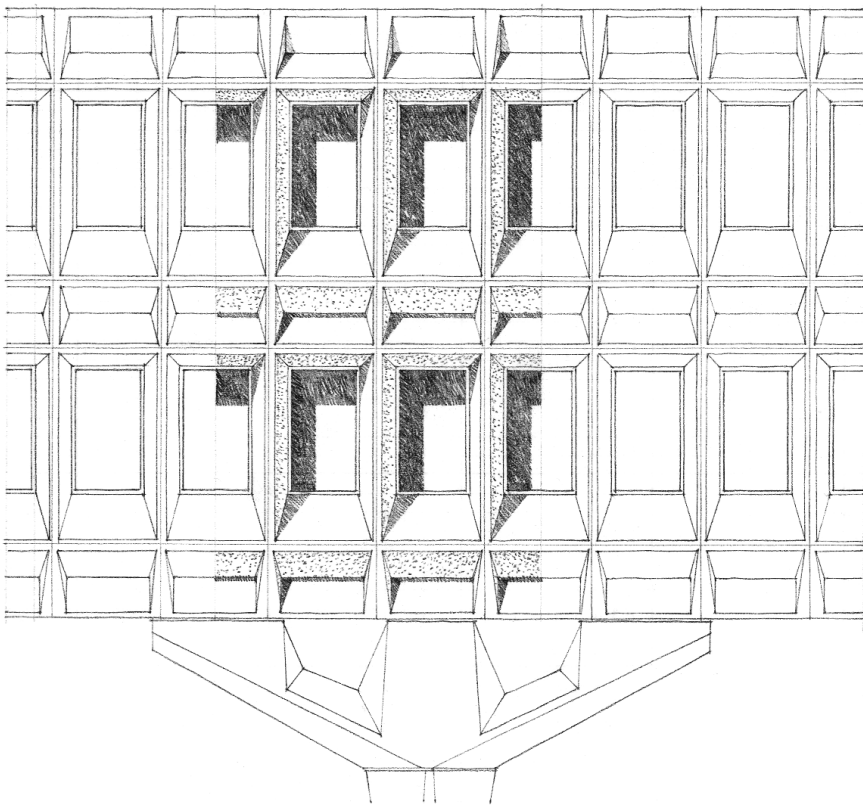
Linear patterns have the ability to emphasize the height or length of a form, unify its surfaces, and define its textural quality.



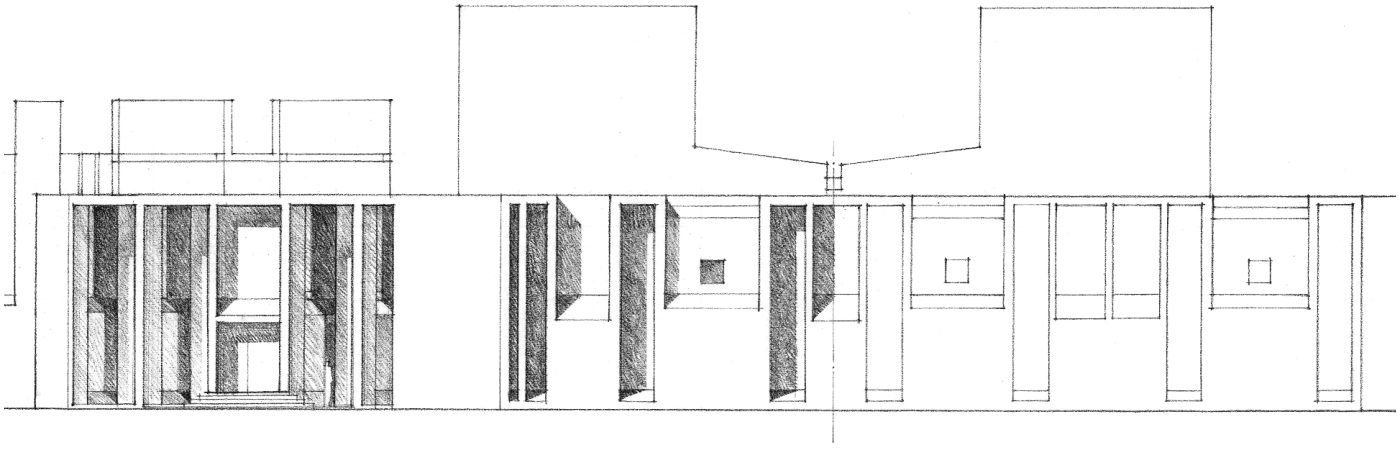
Fukuoka Sogo Bank, Study of the Saga Branch, 1971, Arata Isozaki.
A grid pattern unifies the surfaces of the three-dimensional composition.



A transformation from a pattern of openings in a plane to an open facade articulated by a linear framework.

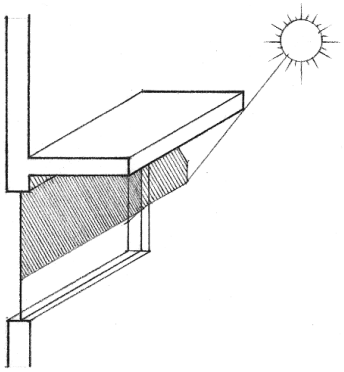


IBM Research Center, La Guade, Var, France, 1960–1961, Marcel Breuer.
The three-dimensional form of the openings creates a pattern of light, shade, and shadows.

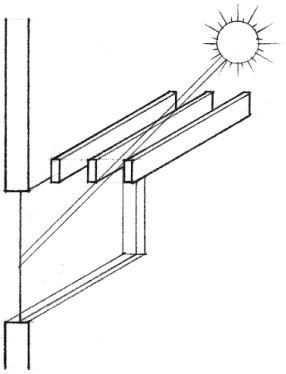


First Unitarian Church, Rochester, New York, 1956–1967, Louis Kahn.
The pattern of openings and cavities interrupts the continuity of the exterior wall planes.

SURFACE ARTICULATION



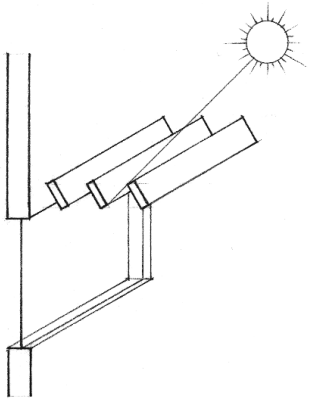
- Horizontal overhangs are most effective when they have southern orientations.



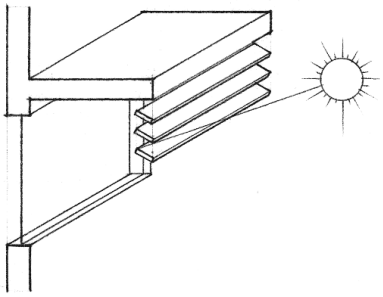
- Horizontal louvers parallel to a wall permit air circulation near the wall and reduce conductive heat gain.
- Louvers may be operated manually or controlled automatically with time or photoelectric controls to adapt to the solar angle.

Shading devices shield windows and other glazed areas from direct sunlight in order to reduce glare and excessive solar heat gain in warm weather. Their effectiveness depends on their form and orientation relative to the solar altitude and azimuth for the time of day and season of the year. Exterior devices are more efficient than those located within interior spaces because they intercept solar rays before they can reach an exterior wall or window.

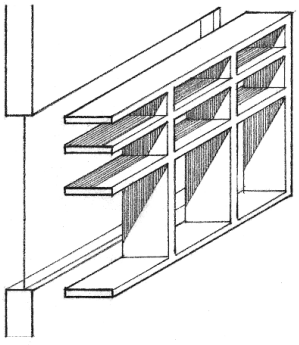
Illustrated are basic types of solar shading devices. Their form, orientation, materials, and construction may vary to suit specific situations. Their visual qualities of pattern, texture, and rhythm, and the shadows they cast, should be considered when designing the facades of a building.



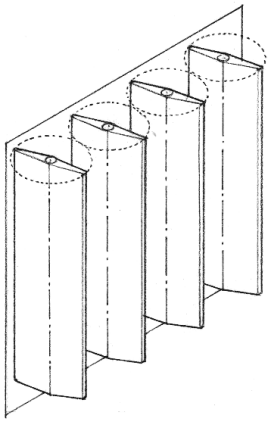
- Slanted louvers provide more protection than those parallel to a wall.
- Angle varies according to the range of solar angles.



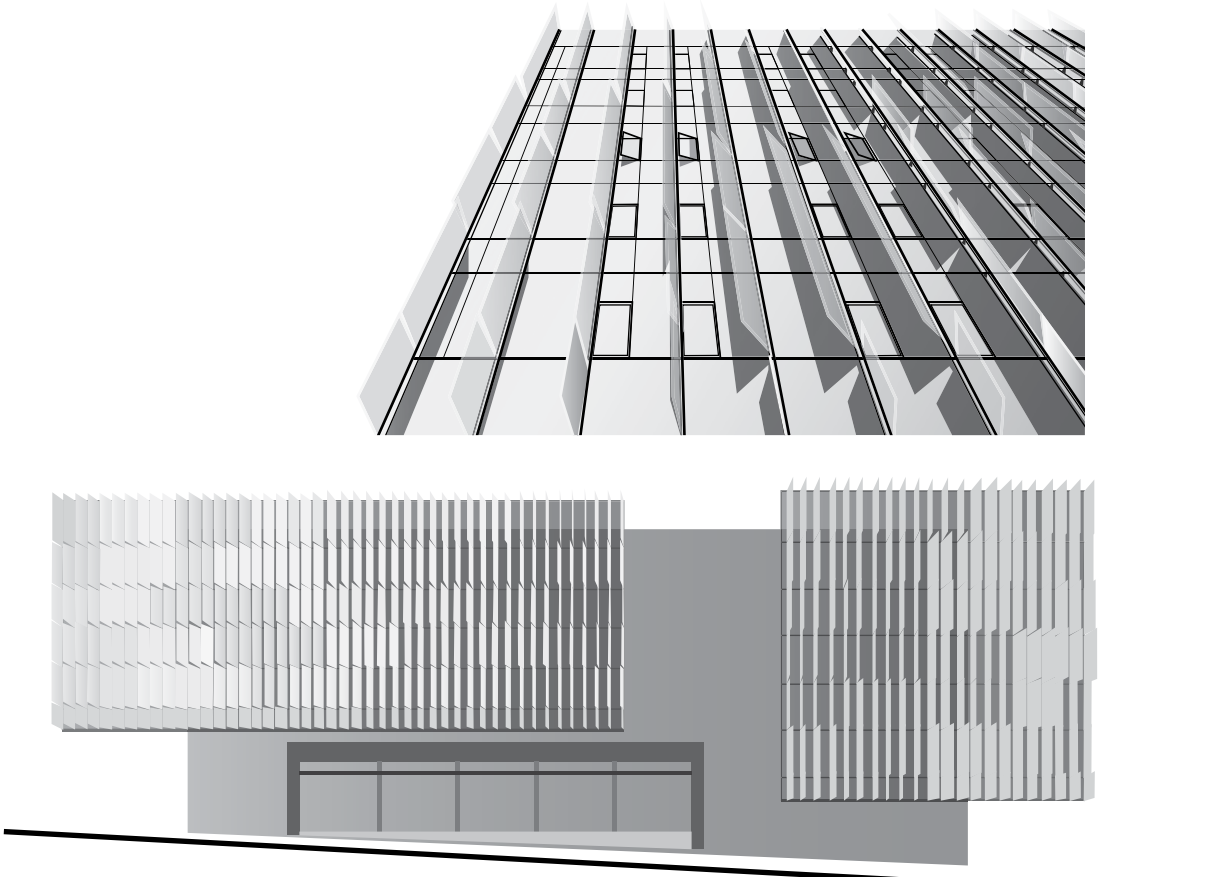
- Louvers hung from a solid overhang protect against low sun angles.
- Louvers may interfere with view.



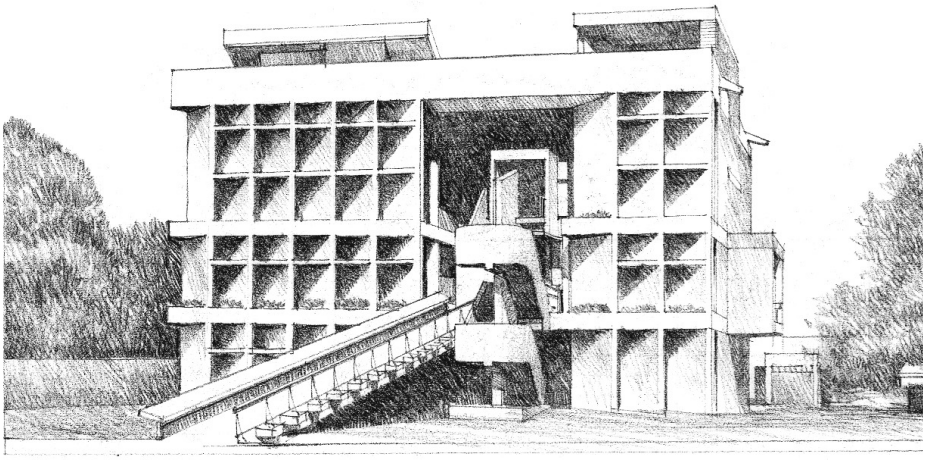
- Eggcrates combine the shading characteristics of horizontal and vertical louvers and have a high shading ratio.
- Eggcrates, sometimes referred to as brise-soleil, are very efficient in hot climates.



- Vertical louvers are most effective for eastern or western exposures.
- Louvers may be operated manually or controlled automatically with time or photoelectric controls to adapt to solar angle.
- Separation from wall reduces conductive heat gain.

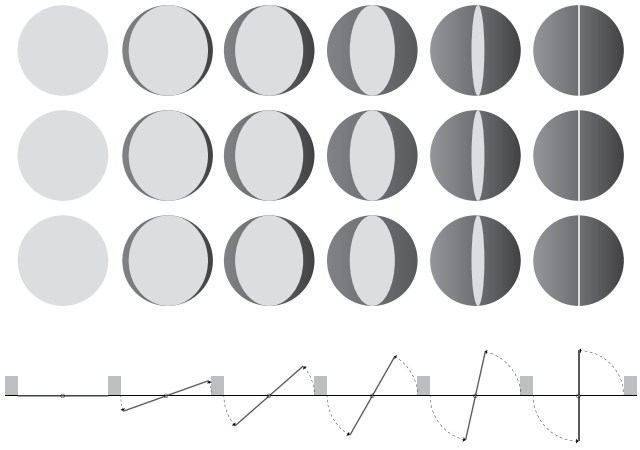


The Hans Rosling Center for Population Health, University of Washington campus, Seattle, Washington, 2020, The Miller Hull Partnership. The vertical sunshading fins are fixed at various angles to form a rhythmic pattern that changes as one drives or walks past the principal facades.



Millowners' Association Building, Ahmedabad, India, 1954, Le Corbusier. See two other examples of how Le Corbusier used brise-soleil in his Shodhan House in Ahmedabad, India (page 70), and Dr. Currutchet's House in La Plata, Argentina (page 292).

SURFACE ARTICULATION



Facades, in defining the front or otherwise special side of buildings, have always played a major role in establishing their visual character, A relatively new development—that of smart facades—continues to function in this manner and introduces a dynamic quality to building aesthetics.

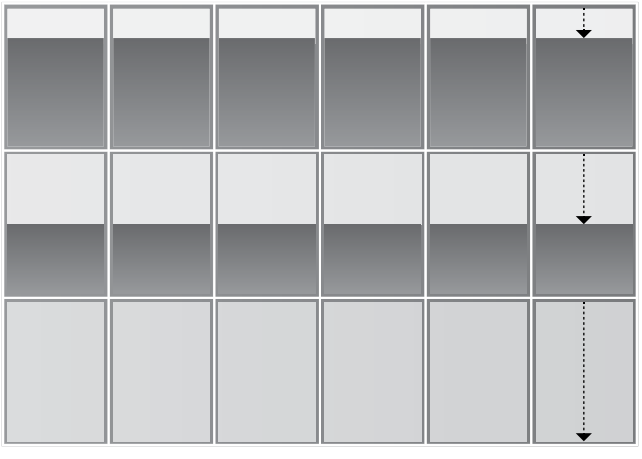
Smart facades incorporate technological advances in the material and chemical sciences that enable them to adapt to environmental situations and transform themselves simultaneously to reduce the energy required for heating, cooling, air conditioning, and lighting a building.

Smart facades can operate in several ways. They can

- Regulate excessive heat gain through solar shading in hot weather.
- Harness solar energy in cold weather.
- Enhance the daylighting of interior spaces.
- Manage natural ventilation for cooling and air quality.
- Generate electricity for building needs.

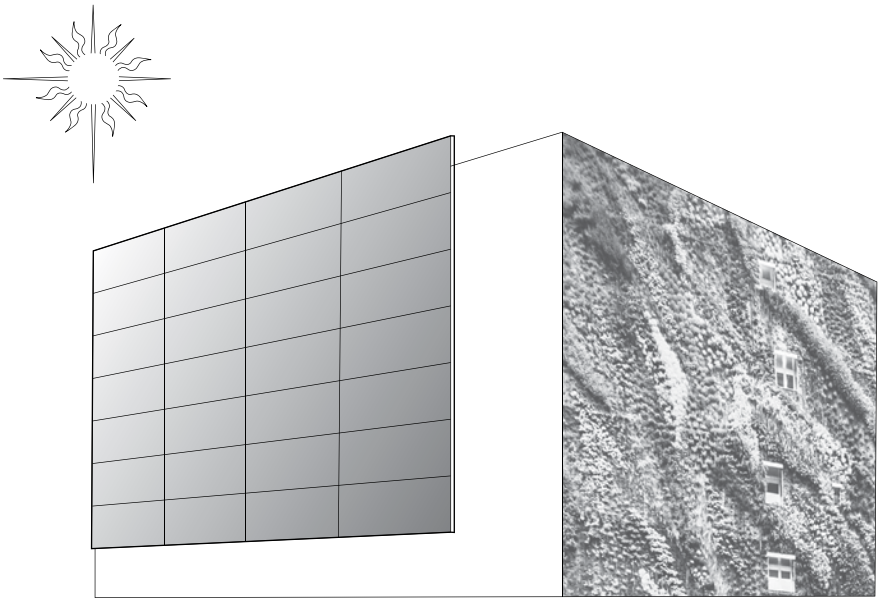
Dynamic or kinetic facades have elements that fold, slide, rotate, or otherwise move to transform themselves in response to environmental conditions. Some systems are controlled manually by users; others are connected to sensors and programmed to respond to environmental conditions.

- Thermally reactive panels open up as shades to moderate overheating from solar gain during hot weather.
- Perforated metal screens adjust their orientation to optimize the daylighting of interior spaces while preserving views.
- Triple-glazed windows have individually operated internal sun blinds; at night, the blinds can be lowered, enabling the thermal value of the facade to emulate that of an insulated wall.



Energy generating glazing or cladding incorporate a thin layer of photovoltaic cells or modules to generate solar energy for use within a building.

- Panels with piezoelectric elements require only a light breeze to cause them to sway and generate power.
- Phase-changing materials offer energy storage for use with renewable energy systems.



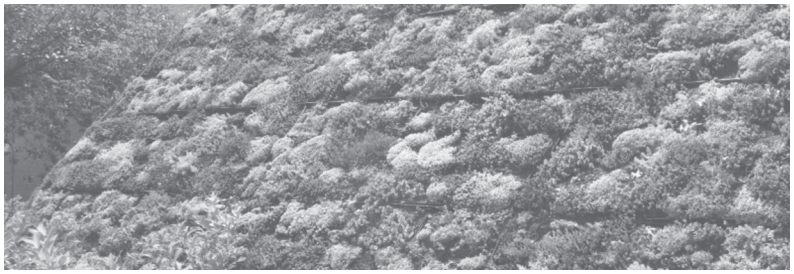
Plant-based technologies use micro-plant life within the double-glazing of a facade that grows rapidly when exposed to sunlight, creating biomass that can be stored and produce methane through the process of anaerobic digestion.

- Plant life provides solar shading and augments thermal insulation for the building envelope.
- Green or living walls are capable of absorbing CO_2 from the atmosphere.

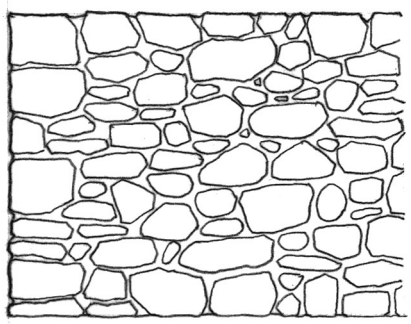
Responsive electrochromic glass and glazing respond to voltage to control the opacity or light transmission properties of the glazing.

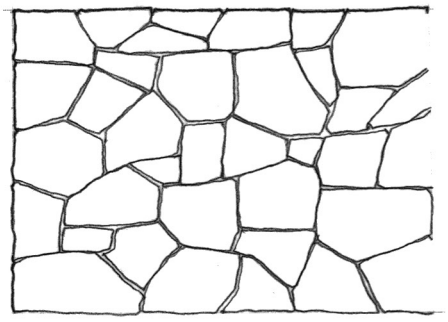
- Thermochromic glass responds directly to the heat from direct sunlight by darkening, similar to the way self-tinting glasses work.
- Polymer Dispersed Liquid Crystal (PDLC) technology uses electricity to change the orientation of suspended liquid crystals to either scatter light or let light pass through when voltage is applied.
- Suspended Particle Devices (SPD) are thin films containing nanoparticles suspended in a liquid. The nanoparticles are normally randomly organized to block and absorb light, but align themselves to allow light to pass through the glass when voltage is applied. The tint of the glazing and the amount of light transmitted can be regulated by varying the voltage.

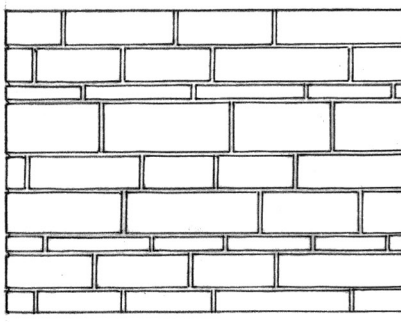
* Translucent insulation products are capable of transmitting visible light while augmenting the thermal insulation of the building envelope.

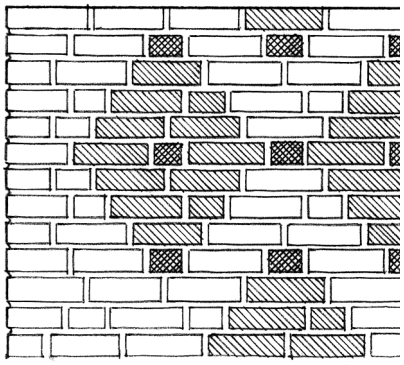


SURFACE ARTICULATION



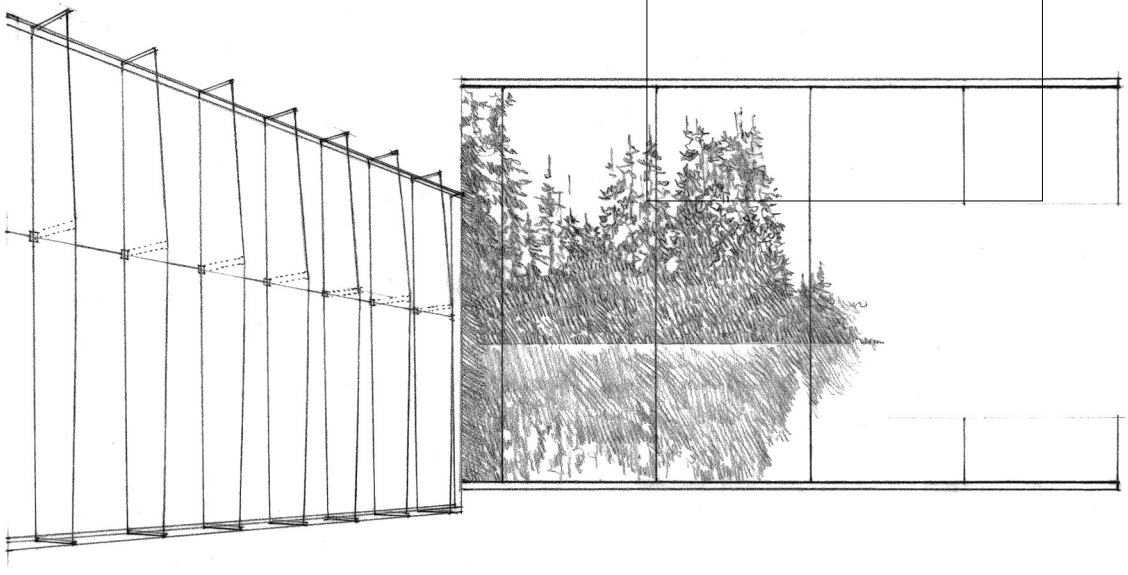


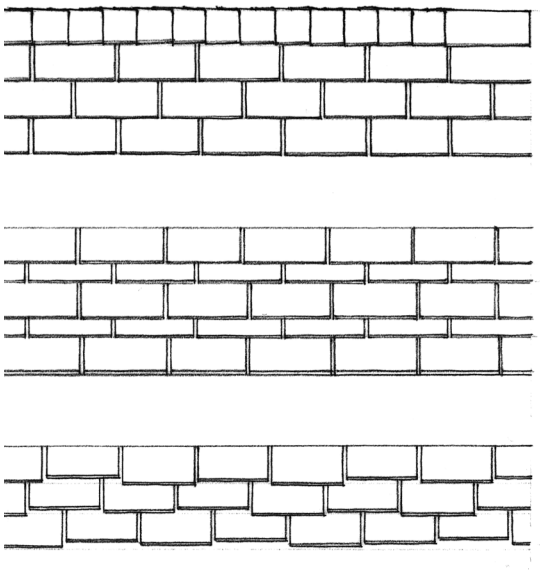


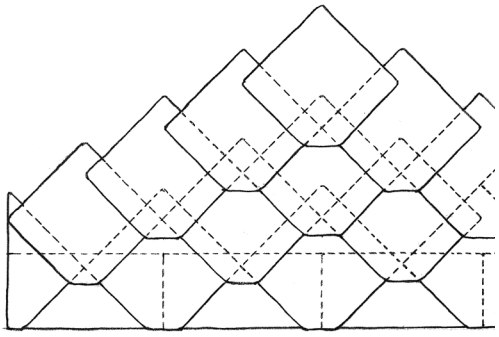


At a smaller scale, the surfaces of buildings owe their visual characteristics to the way their materials are joined and assembled in construction.

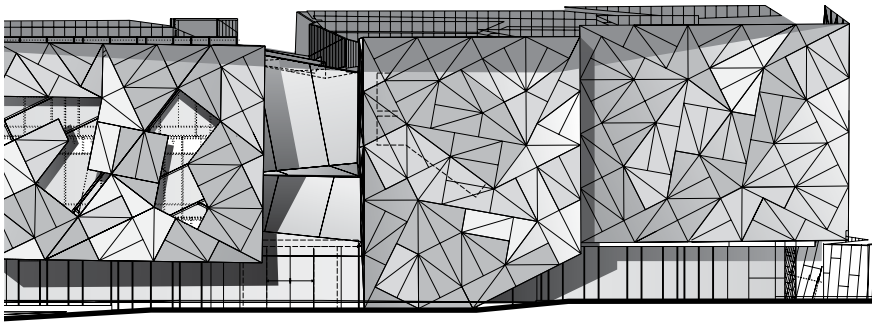
From rough to smooth…



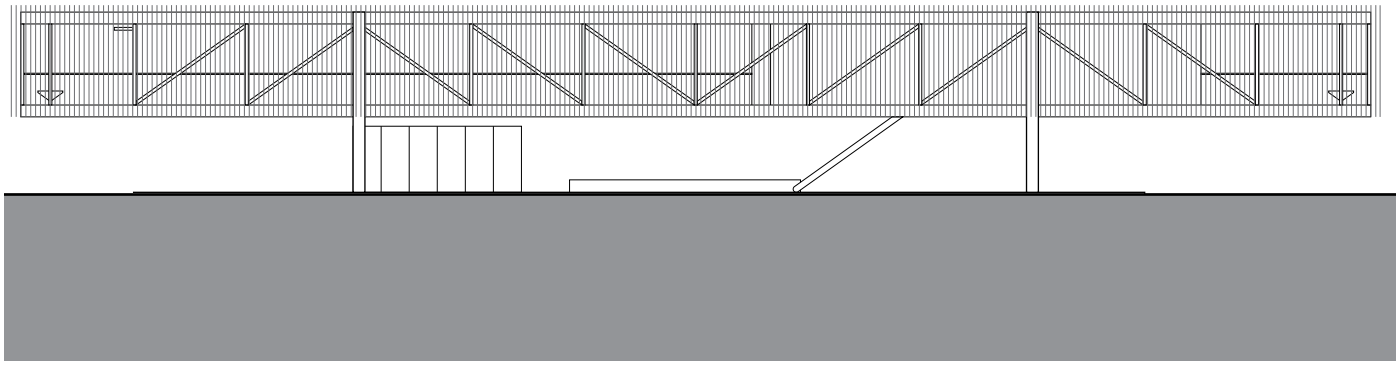




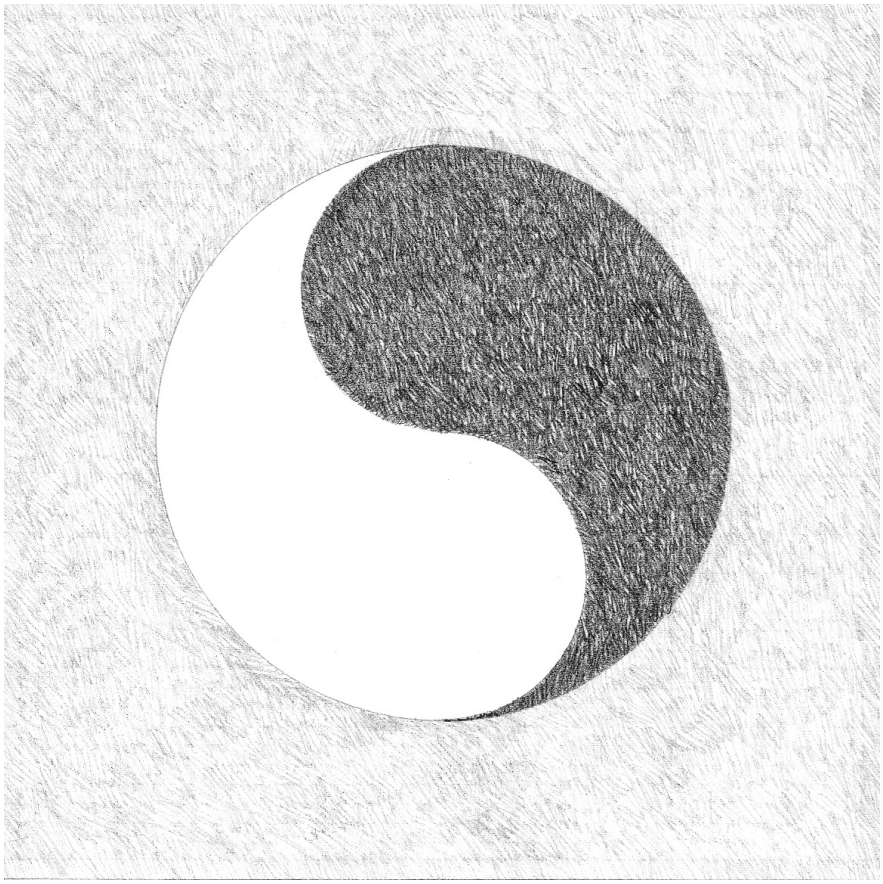
From orthogonal to skewed…



Partial facade, **Federation Square**, Melbourne, Australia, 2003, LAB Architecture Studio & Bates Smart, Architects



St. Andrew's Beach House, Victoria, Australia, 2006, Sean Godsell Architects



3

Form & Space

"We put thirty spokes together and call it a wheel;
but it is on the space where there is nothing
that the utility of the wheel depends.
We turn clay to make a vessel;
but it is on the space where there is nothing
that the utility of the vessel depends.
We pierce doors and windows to make a house;
and it is on these spaces where there is nothing
that the utility of the house depends.
Therefore, just as we take advantage of what is,
we should recognize the utility of what is not."

Lao-tzu
Tao Te Ching
6th century B.C.

Architecture: Form, Space, & Order, Fifth Edition. Francis D. K. Ching.
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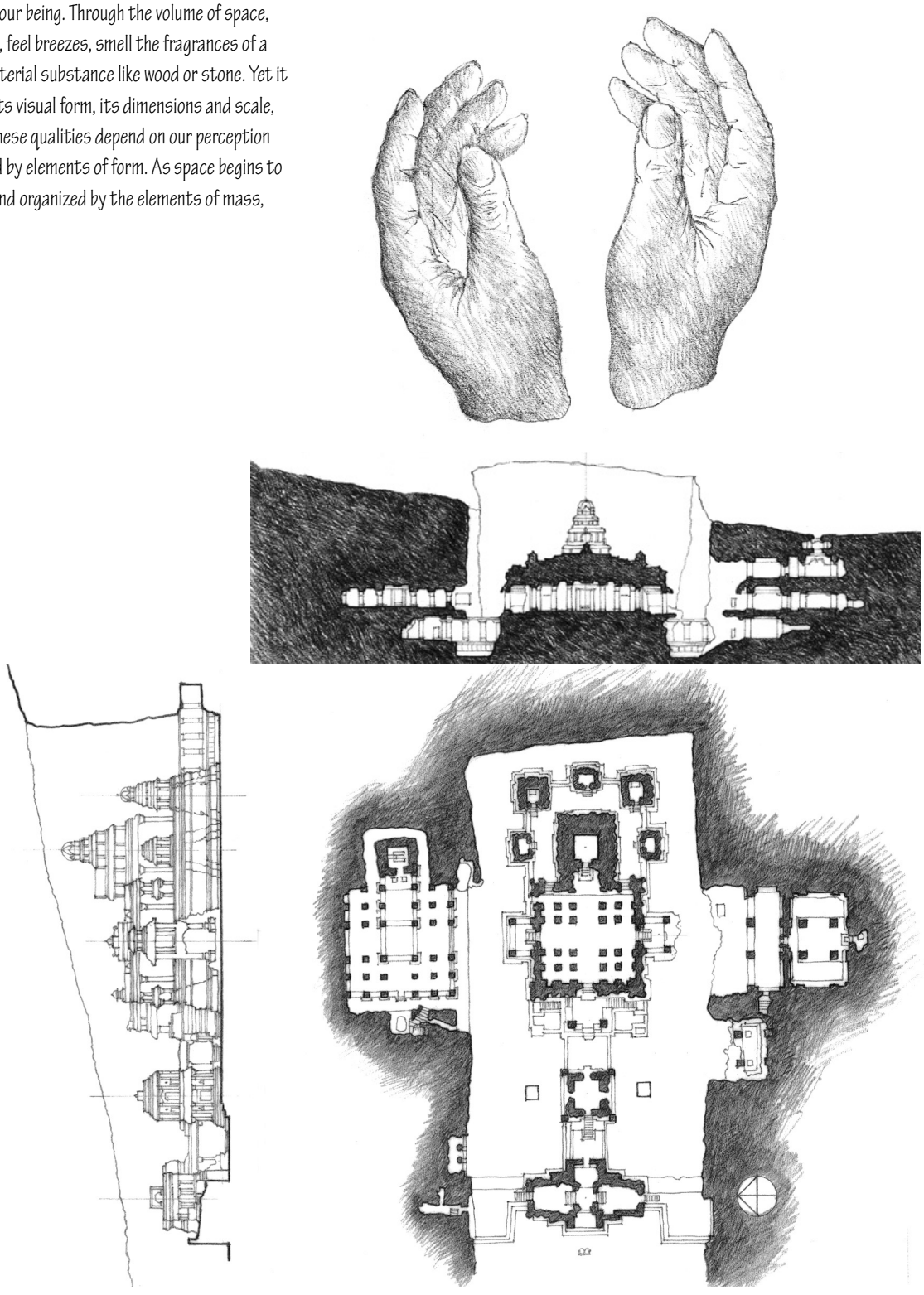
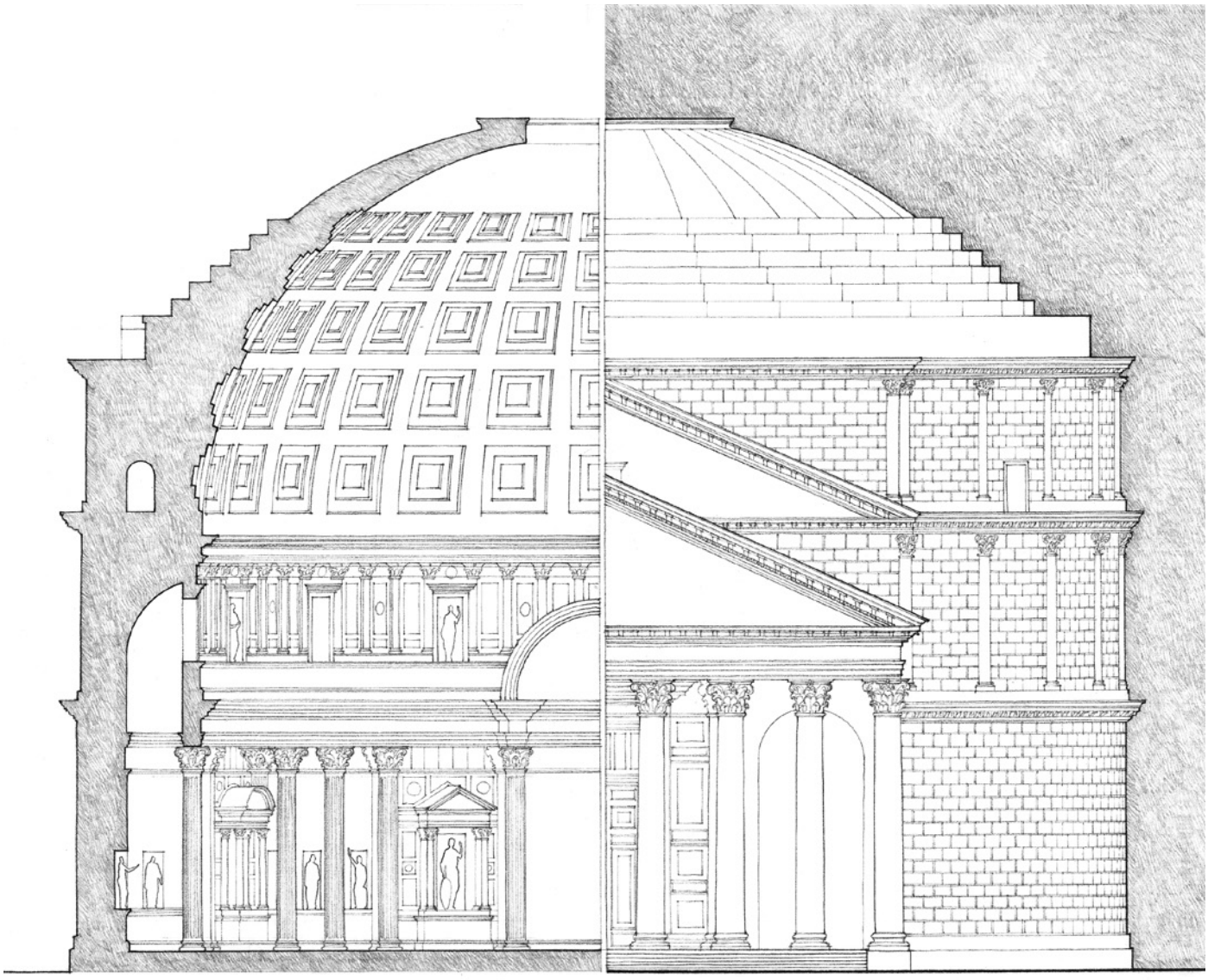
Companion Website: www.wiley.com/go/ching/architecturefso5e

FORM & SPACE

Space constantly encompasses our being. Through the volume of space, we move, see forms, hear sounds, feel breezes, smell the fragrances of a flower garden in bloom. It is a material substance like wood or stone. Yet it is an inherently formless vapor. Its visual form, its dimensions and scale, the quality of its light—all of these qualities depend on our perception of the spatial boundaries defined by elements of form. As space begins to be captured, enclosed, molded, and organized by the elements of mass, architecture comes into being.

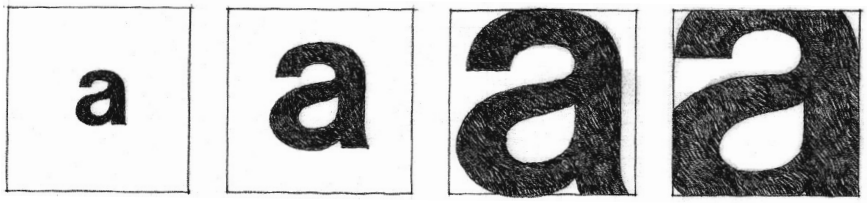


Temple of Kailasnath at Ellora, near Aurangabad, India, A.D. 600–1000

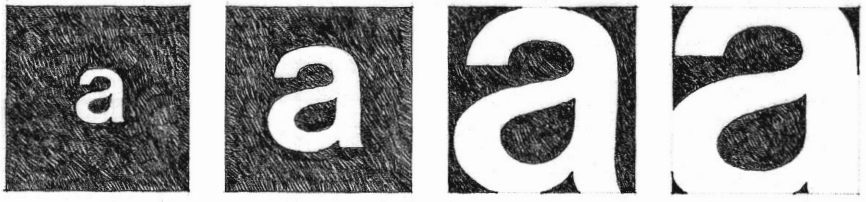


The Pantheon, *Rome, A.D. 120–124*

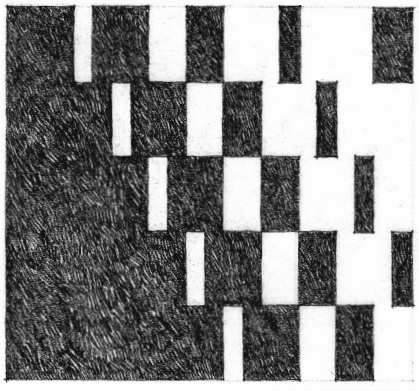
FORM & SPACE: THE UNITY OF OPPOSITES



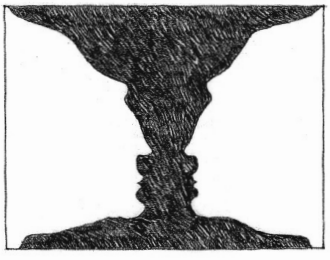
Our visual field normally consists of heterogeneous elements that differ in shape, size, color, or orientation. To better comprehend the structure of a visual field, we tend to organize its elements into two opposing groups: positive elements, which are perceived as figures and negative elements, which provide a background for the figures.



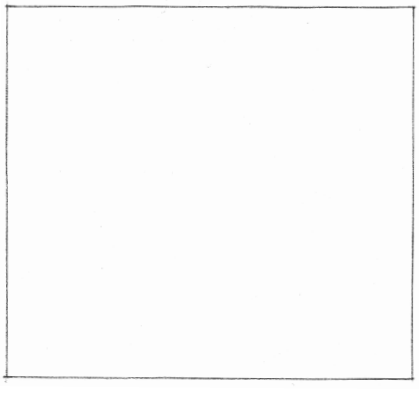
Our perception and understanding of a composition depends on how we interpret the visual interaction between the positive and negative elements within its field. On this page, for example, letters are seen as dark figures against the white background of the paper surface. Consequently, we are able to perceive their organization into words, sentences, and paragraphs. In the diagrams to the left, the letter "a" is seen as a figure not only because we recognize it as a letter in our alphabet but also because its profile is distinct, its value contrasts with that of its background, and its placement isolates it from its context. As it grows in size relative to its field, however, other elements within and around it begin to compete for our attention as figures. At times, the relationship between figures and their background is so ambiguous that we visually switch their identities back and forth almost simultaneously.

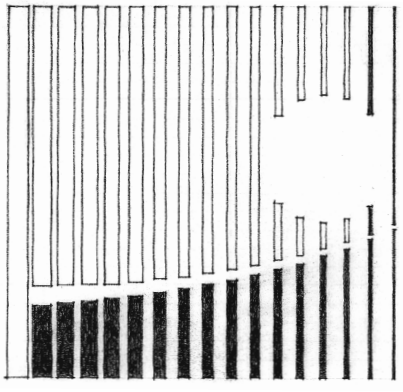


White-on-Black or Black-on-White?



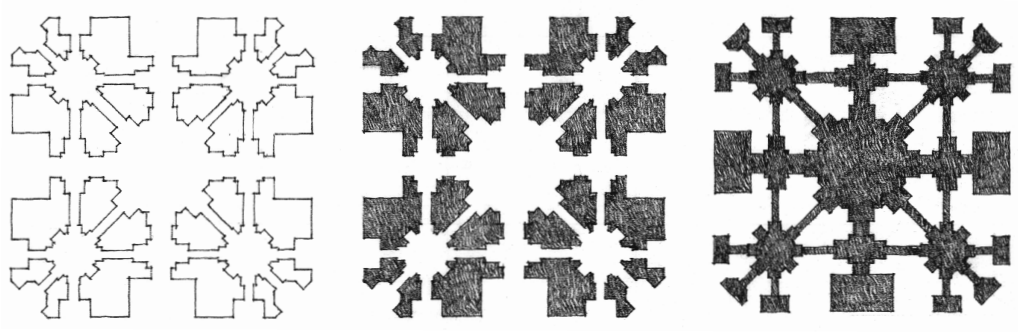
Two Faces or a Vase?





In all cases, however, we should understand that figures, the positive elements that attract our attention, could not exist without a contrasting background. Figures and their background, therefore, are more than opposing elements. Together, they form an inseparable reality—a unity of opposites—just as the elements of form and space together form the reality of architecture.

Plan Diagrams, **Taj Mahal**, Agra, India, 1630–1653. Shah Jahan built this white marble mausoleum for his favorite wife, Muntaz Mahal.



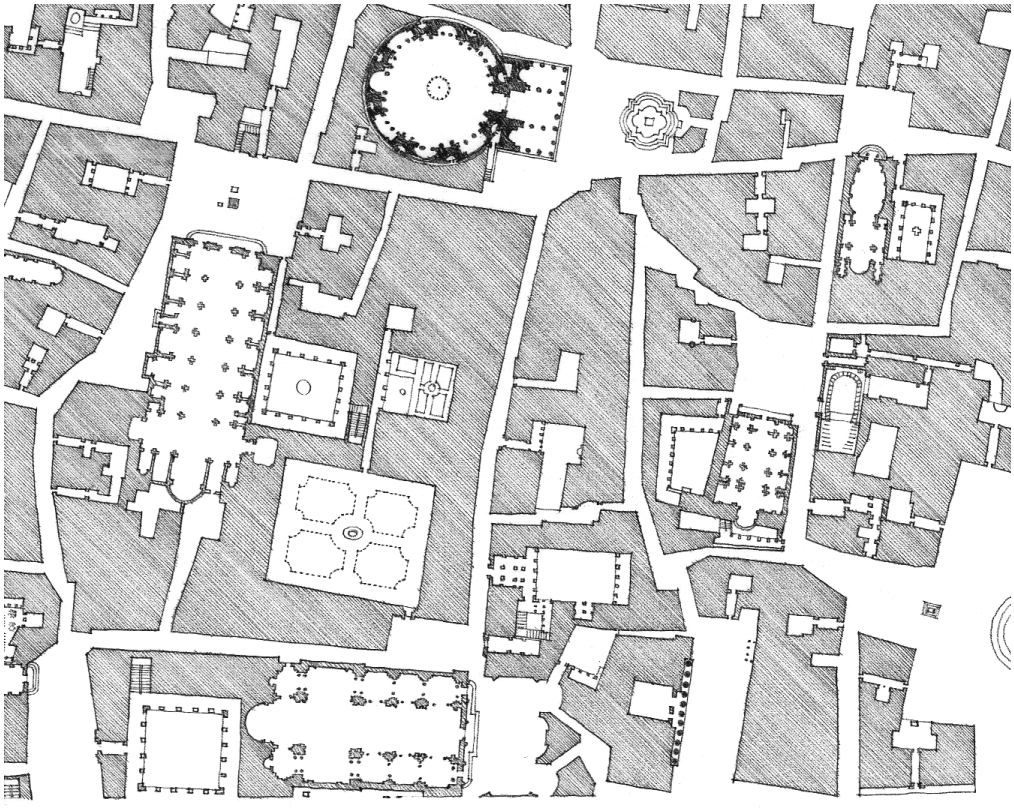
A. Line defining the boundary between solid mass and spatial void

B. The form of solid mass rendered as a figure

C. The form of the spatial void rendered as a figure

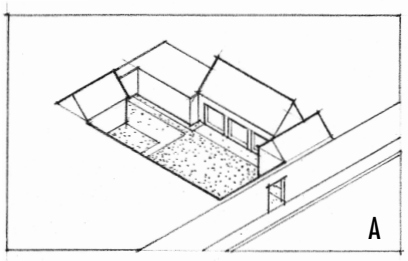
Architectural form occurs at the juncture between mass and space. In executing and reading design drawings, we should be concerned with both the form of the mass containing a volume of space as well as the form of the spatial volume itself.

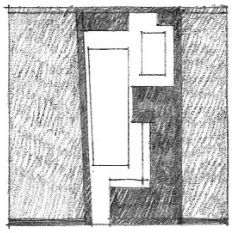
Fragment of a **Map of Rome**, drawn by Giambattista Nolli in 1748

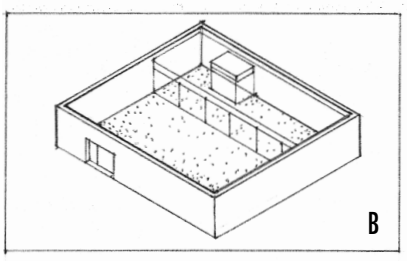


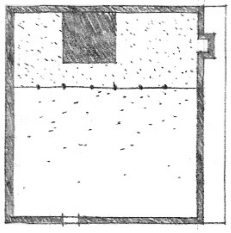
Depending on what we perceive to be positive elements, the figure-ground relationship of the forms of mass and space can be inverted in different parts of this map of Rome. In portions of the map, buildings appear to be positive forms that define street spaces. In other parts of the drawing, urban squares, courtyards, and major spaces within important public buildings read as positive elements seen against the background of the surrounding building mass.

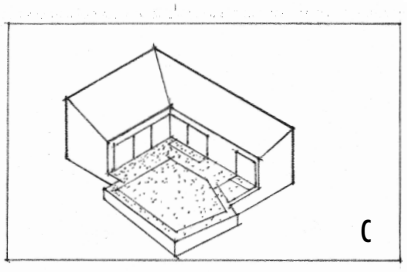
FORM & SPACE: THE UNITY OF OPPOSITES

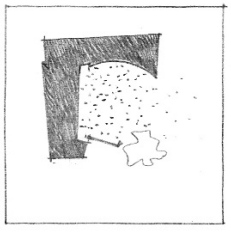


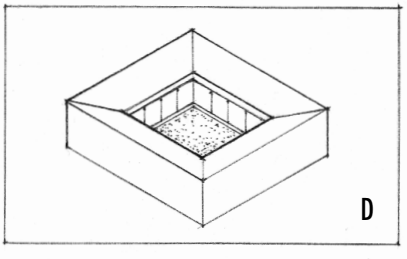


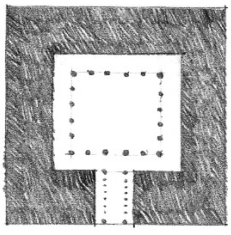












The symbiotic relationship of the forms of mass and space in architecture can be examined and found to exist at several different scales. At each level, we should be concerned not only with the form of a building but also its impact on the space around it. At an urban scale, we should carefully consider whether the role of a building is to continue the existing fabric of a place, form a backdrop for other buildings, or define a positive urban space, or whether it might be appropriate for it to stand free as a significant object in space.

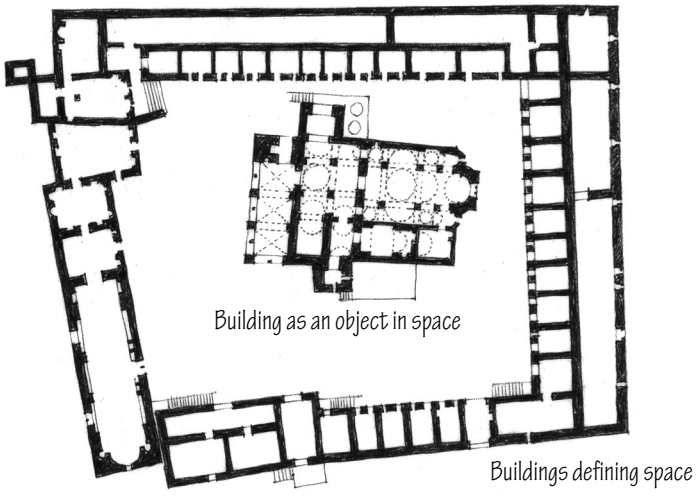
At the scale of a building site, there are various strategies for relating the form of a building to the space around it. A building can:

A. Form a wall along an edge of its site and begin to define a positive outdoor space.

B. Merge its interior space with the private outdoor space of a walled site.

C. Enclose a portion of its site as an outdoor room and shelter it from undesirable climatic conditions.

D. Surround and enclose a courtyard or atrium space within its volume—an introverted scheme.

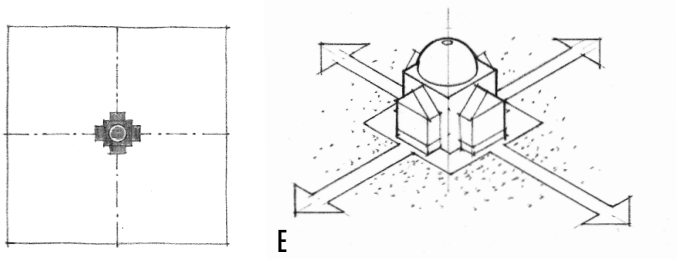


Building as an object in space

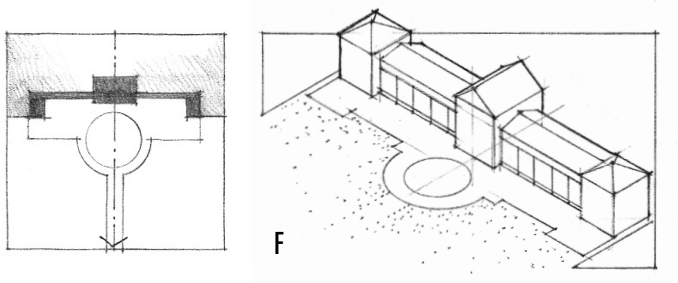
Buildings defining space

Monastery of St. Meletios on Mt. Kithairon, Greece, 9th century A.D.

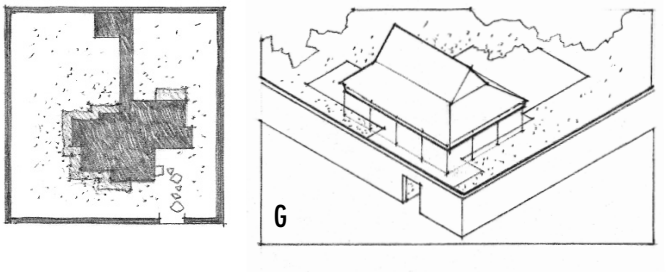
E. Stand as a distinct object in space and dominate its site through its form and topographical positioning—an extroverted scheme.



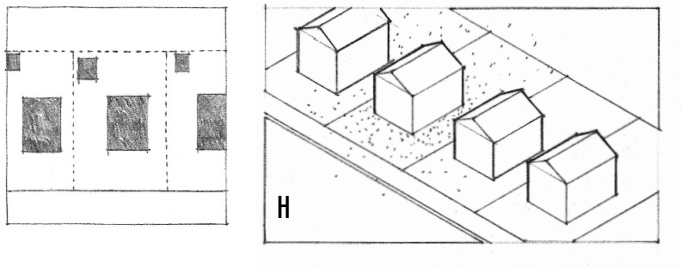
F. Stretch out and present a broad face to address a view, terminate an axis, or define an edge of an urban space.

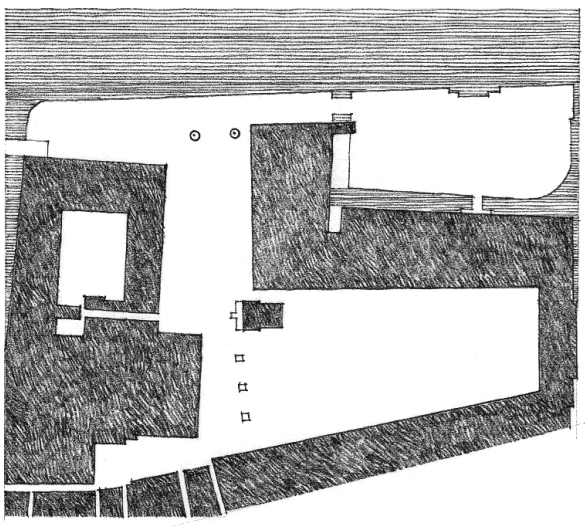


G. Stand free within its site but extend its interior spaces to merge with private exterior spaces.

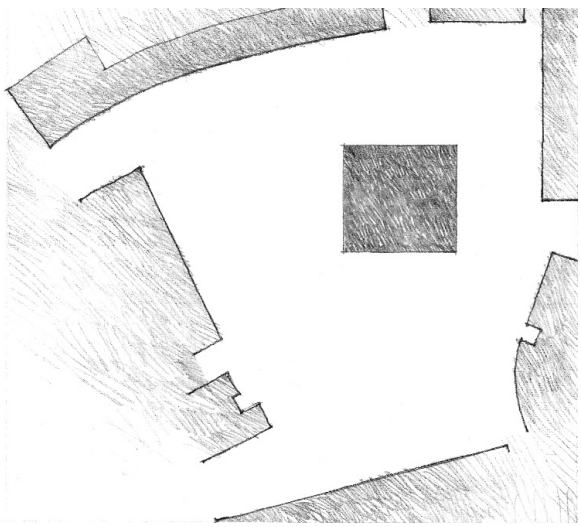


H. Stand as a positive form in a negative space.

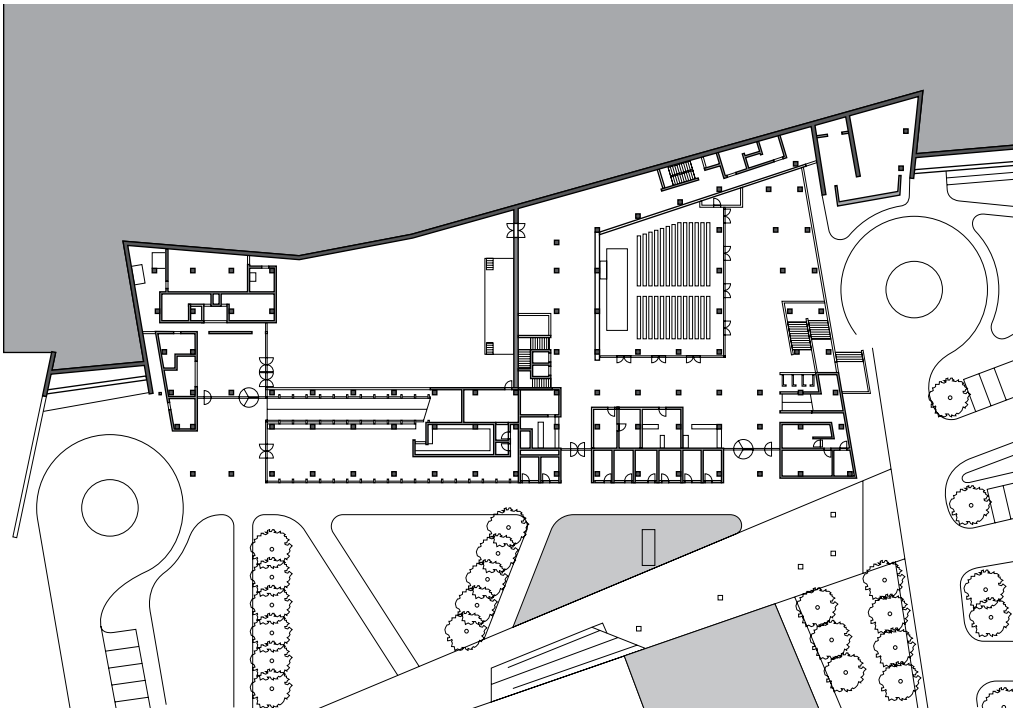




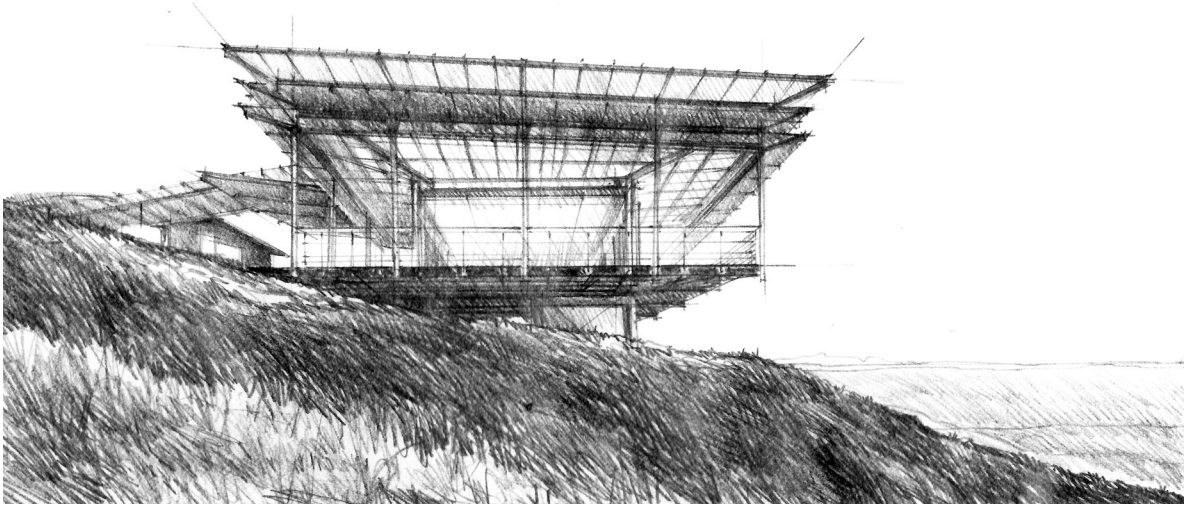
Buildings Defining Space:
***Piazza San Marco**, Venice*



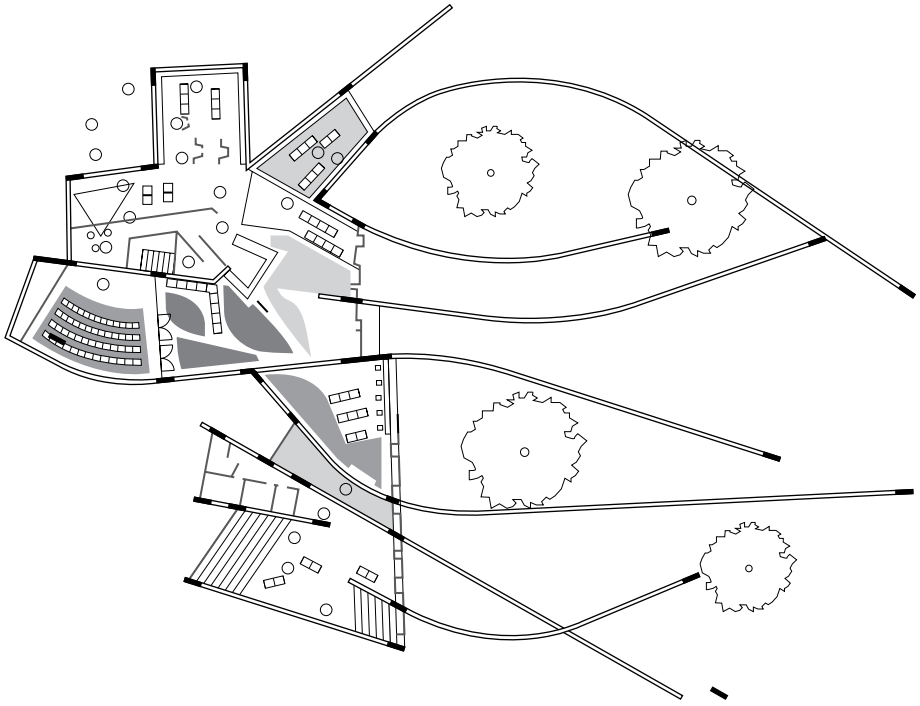
Building as an Object in Space:
***Boston City Hall**, 1960, Kallmann, McKinnell & Knowles*



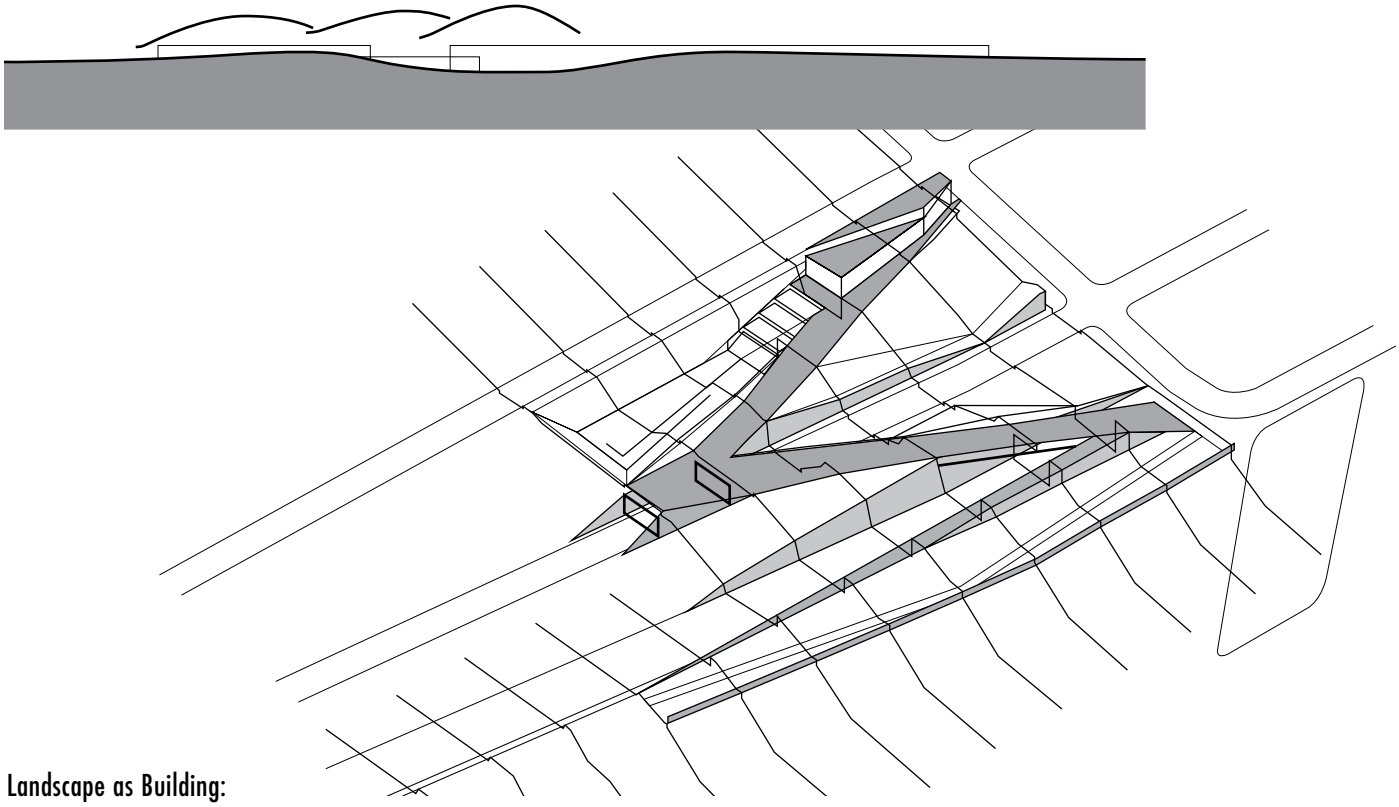
Building Embedded in the Landscape:
Eyüp Cultural Center, Istanbul, Turkey, 2013, EAA-Emre Arolat Architects



Building Dominating the Landscape:
Cooroy Art Temple, Cooroy Mountain, Australia, 2008, Paolo Denti JMA Architects

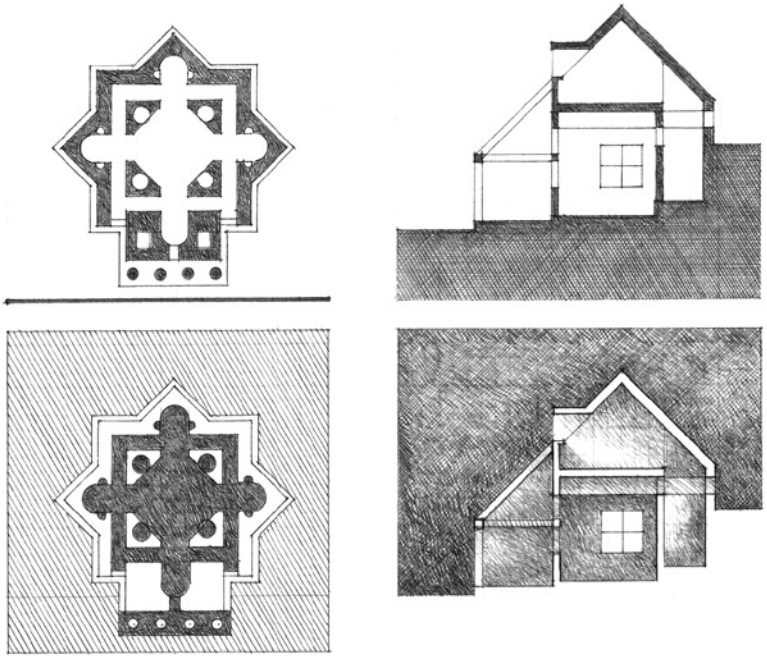


Building as Landscape:
Palafolls Public Library, Palafolls, Spain, 2009, Enric Miralles and Benedetta Tagliabue/Miralles Tagliabue EMBT

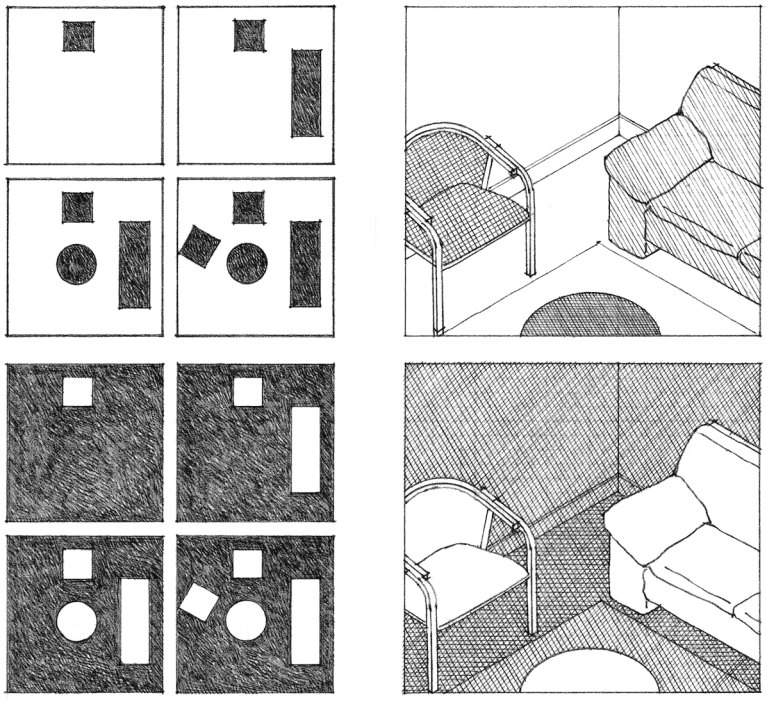


Landscape as Building:
Olympic Sculpture Park, Seattle Art Museum, Seattle, Washington, 2008, Weiss/Manfredi Architecture/Landscape/Urbanism

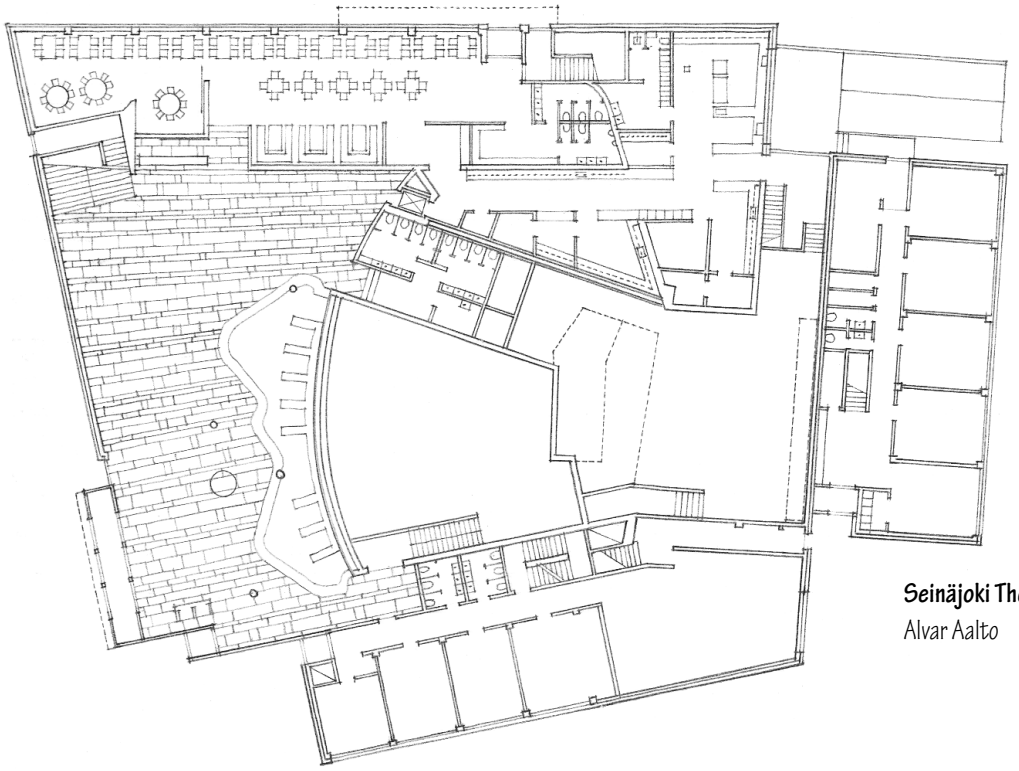
FORM & SPACE: THE UNITY OF OPPOSITES



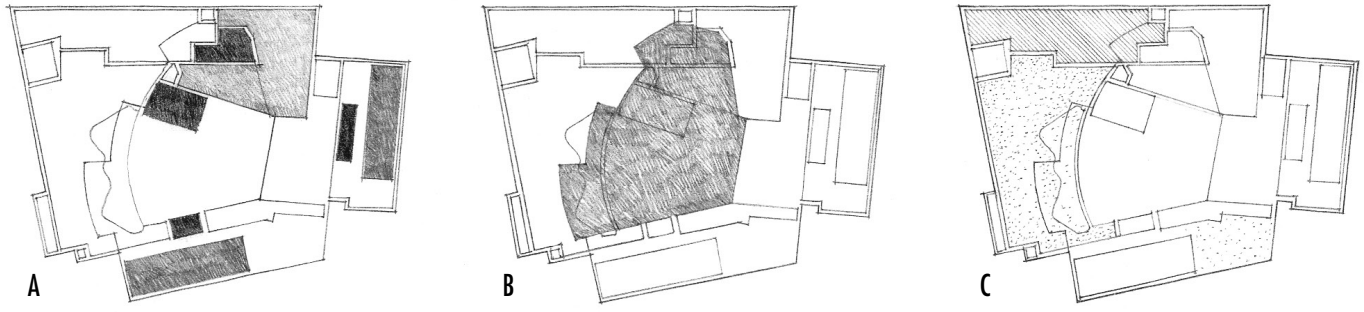
At the scale of a building, we tend to read the configurations of walls as the positive elements of a plan. The white space in between, however, should not be seen simply as background for the walls, but also as figures in the drawing that have shape and form.



Even at the scale of a room, articles of furnishings can either stand as forms within a field of space or serve to define the form of a spatial field.



Seinäjoki Theater, Finland, 1968–1969, Alvar Aalto



The form and enclosure of each space in a building either determines, or is determined by, the form of the spaces around it. In the Theater in Seinäjoki by Alvar Aalto, for example, we can distinguish several categories of spatial forms and analyze how they interact. Each category has an active or passive role in defining space:

A. Some spaces, such as offices, have specific but similar functions and can be grouped into single, linear, or clustered forms.
B. Some spaces, such as concert halls, have specific functional and technical requirements, and require specific forms that will affect the forms of the spaces around them.
C. Some spaces, such as lobbies, are flexible in nature and can therefore be freely defined by the spaces or grouping of spaces around them.

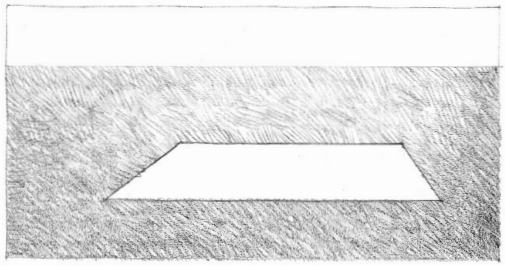
FORM DEFINING SPACE

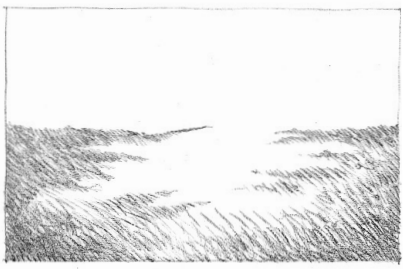
Square in Giron, Colombia, South America

When we place a two-dimensional figure on a piece of paper, it influences the shape of the white space around it. In a similar manner, any three-dimensional form naturally articulates the volume of space surrounding it and generates a field of influence or territory that it claims as its own. The following section looks at horizontal and vertical elements of form and presents examples of how various configurations of these formal elements generate and define specific types of space.

Base Plane

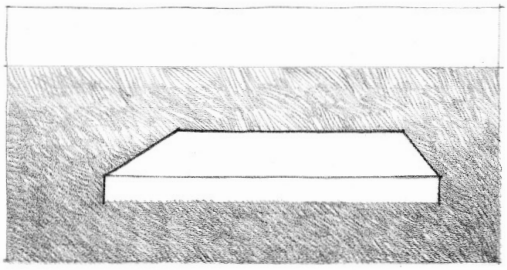
A horizontal plane laying as a figure on a contrasting background defines a simple field of space. This field can be visually reinforced in the following ways.

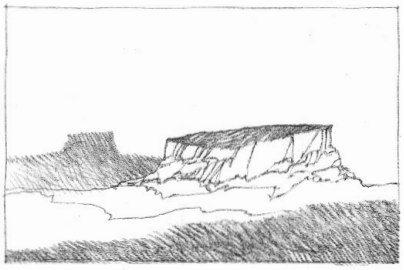




Elevated Base Plane

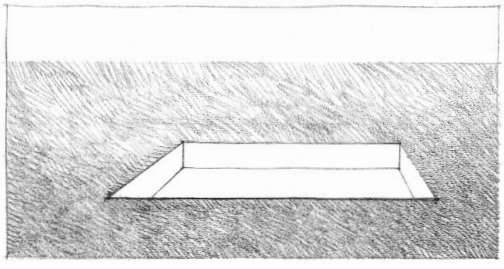
A horizontal plane elevated above the ground plane establishes vertical surfaces along its edges that reinforce the visual separation between its field and the surrounding ground.

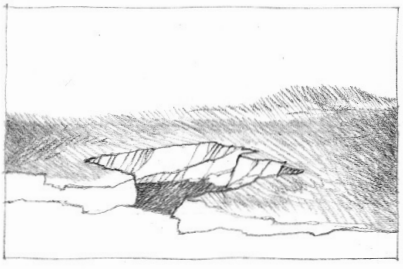




Depressed Base Plane

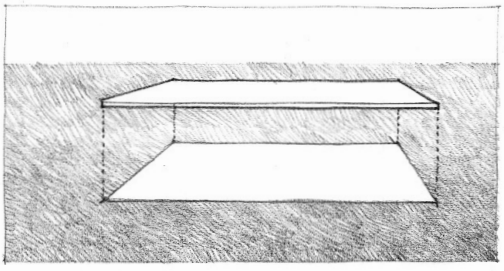
A horizontal plane depressed into the ground plane utilizes the vertical surfaces of the lowered area to define a volume of space.

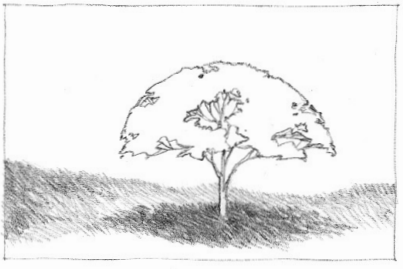




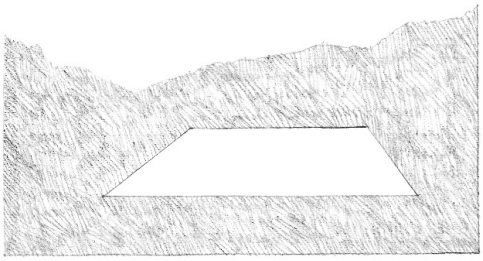
Overhead Plane

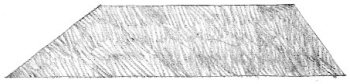
A horizontal plane located overhead defines a volume of space between itself and the ground plane.



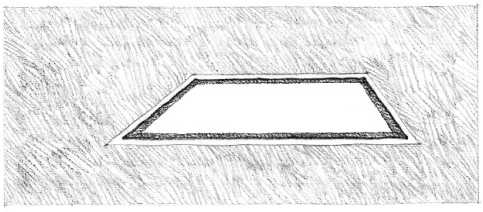


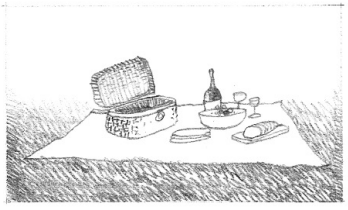
BASE PLANE



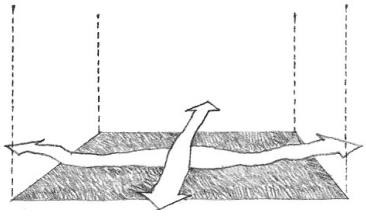


For a horizontal plane to be seen as a figure, there must be a perceptible change in color, tone, or texture between its surface and that of the surrounding area.

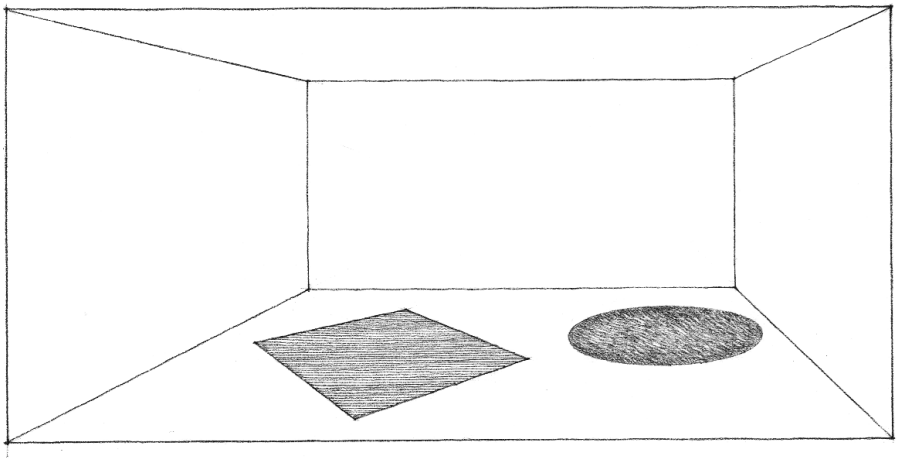




The stronger the edge definition of a horizontal plane is, the more distinct will be its field.

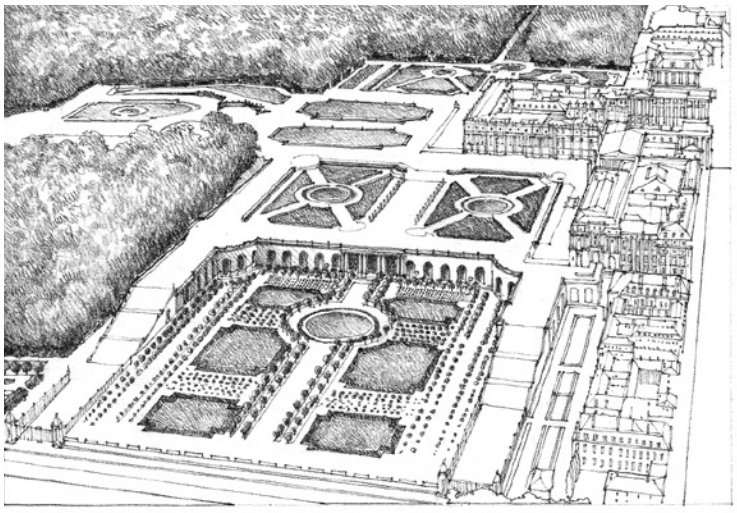


Although there is a continuous flow of space across it, the field nevertheless generates a spatial zone or realm within its boundaries.

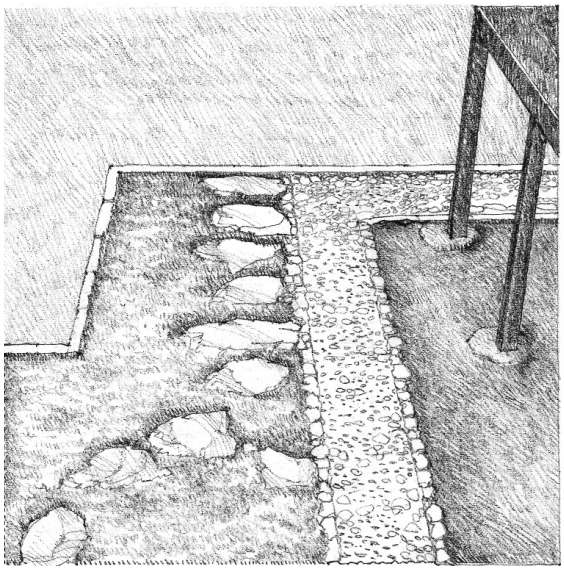


The surface articulation of the ground or floor plane is often used in architecture to define a zone of space within a larger context. The examples on the facing page illustrate how this type of spatial definition can be used to differentiate between a path of movement and places of rest, establish a field from which the form of a building rises out of the ground, or articulate a functional zone within a one-room living environment.

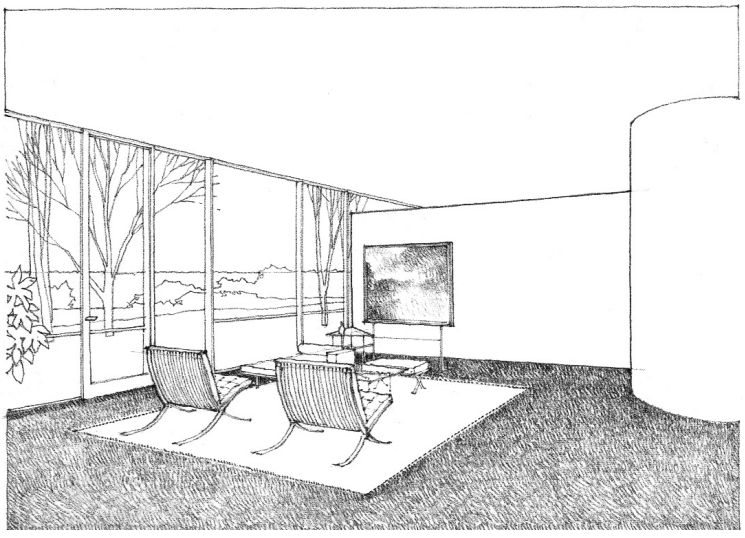
Street in Woodstock, Oxfordshire, England



Parterre de Broderie, **Palace of Versailles**, France, 17th century, André Le Nôtre

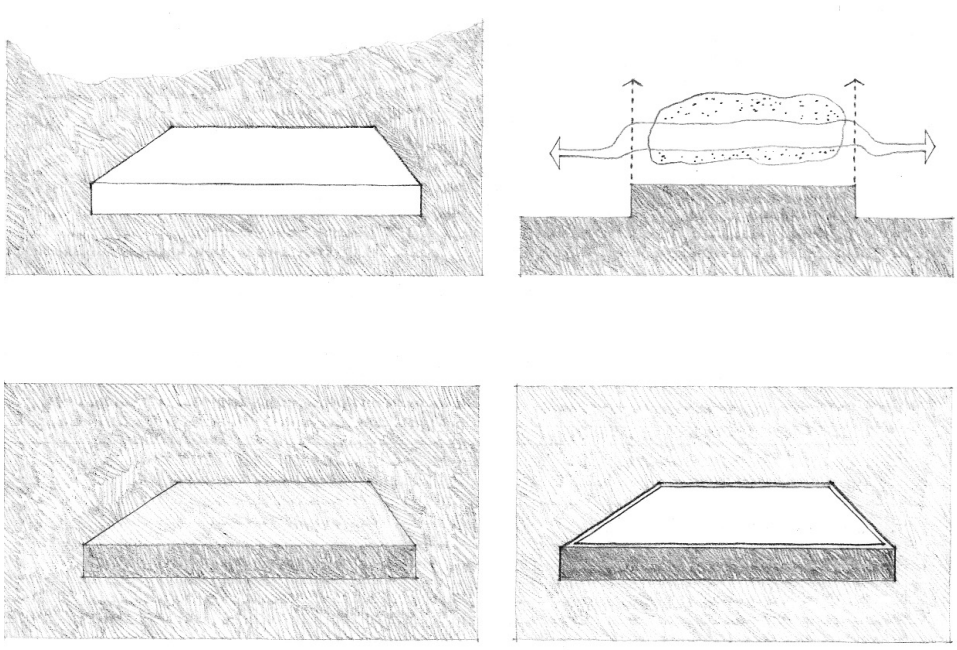


Katsura Imperial Villa, Kyoto, Japan, 17th century



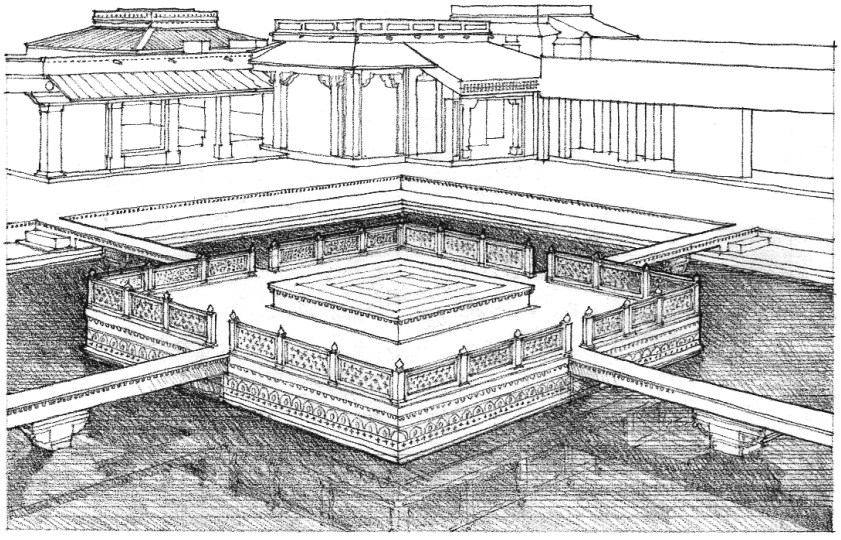
Interior of **Glass House**, New Canaan, Connecticut, 1949, Philip Johnson

ELEVATED BASE PLANE



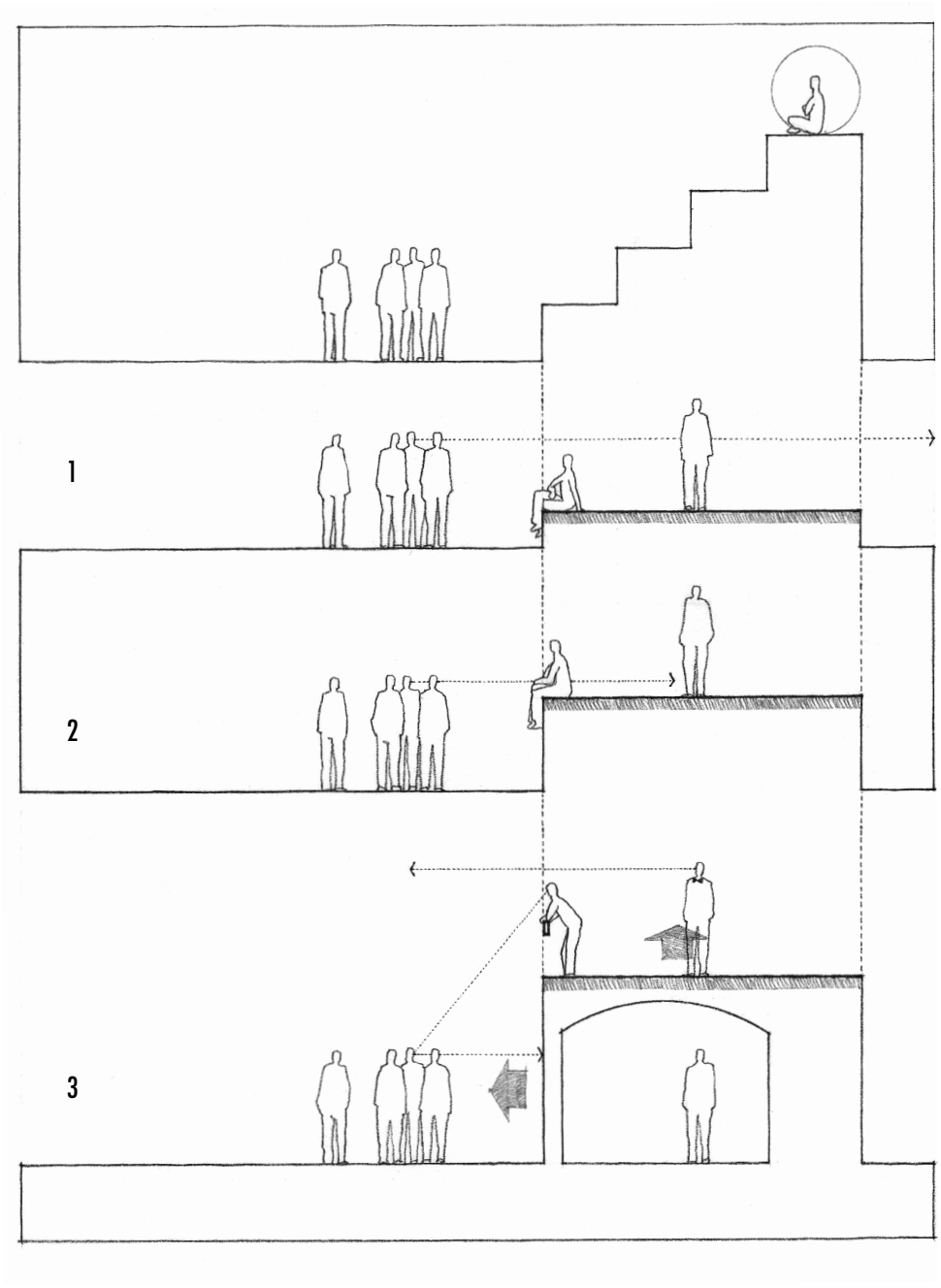
Elevating a portion of the base plane creates a specific domain within a larger spatial context. The changes in level that occur along the edges of the elevated plane define the boundaries of its field and interrupt the flow of space across its surface.

If the surface characteristics of the base plane continue up and across the elevated plane, then the field of the elevated plane will appear to be very much a part of the surrounding space. If, however, the edge condition is articulated by a change in form, color, or texture, then the field will become a plateau that is separate and distinct from its surroundings.



Fatehpur Sikri, Palace Complex of Akbar the Great, Mogul Emperor of India, 1569–1574. A special place is established by a platform in an artificial lake surrounded by the emperor's living and sleeping quarters.

The degree to which spatial and visual continuity is maintained between an elevated space and its surroundings depends on the scale of the level change.

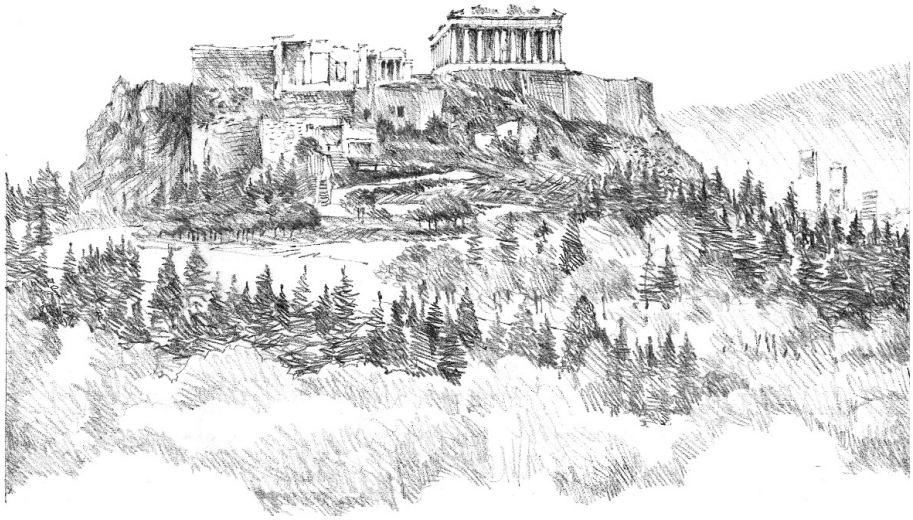


1. The edge of the field is well-defined; visual and spatial continuity is maintained; physical access is easily accommodated.

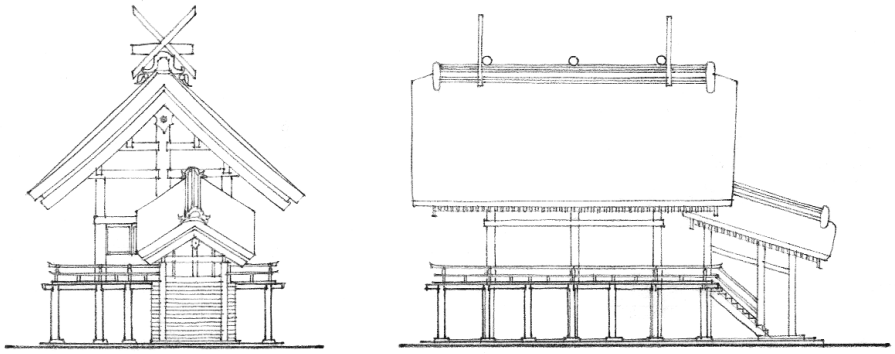
2. Visual continuity is maintained; spatial continuity is interrupted; physical access requires the use of stairs or ramps.

3. Visual and spatial continuity is interrupted; the field of the elevated plane is isolated from the ground or floor plane; the elevated plane is transformed into a sheltering element for the space below.

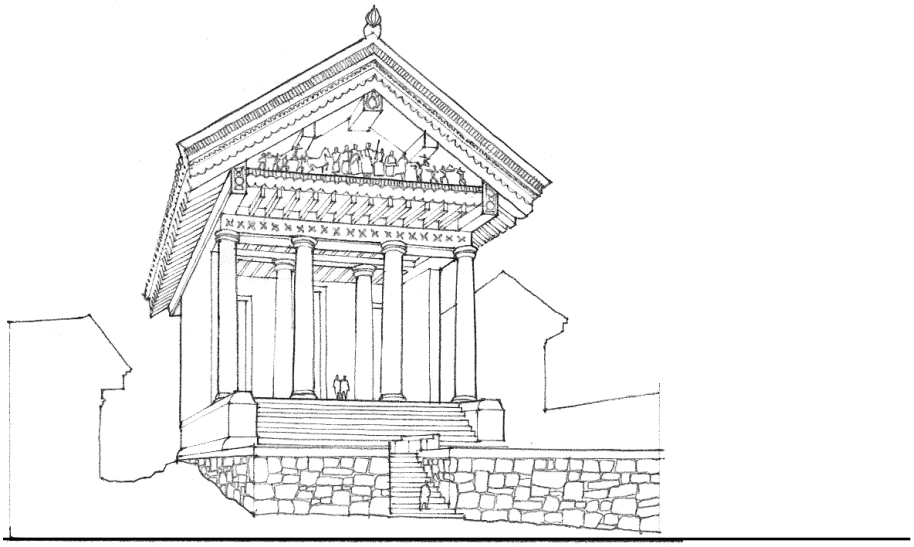
ELEVATED BASE PLANE



The Acropolis, the citadel of Athens, 5th century B.C.

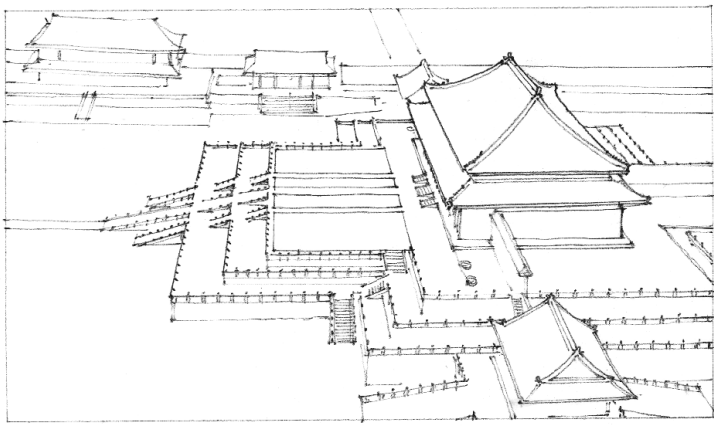


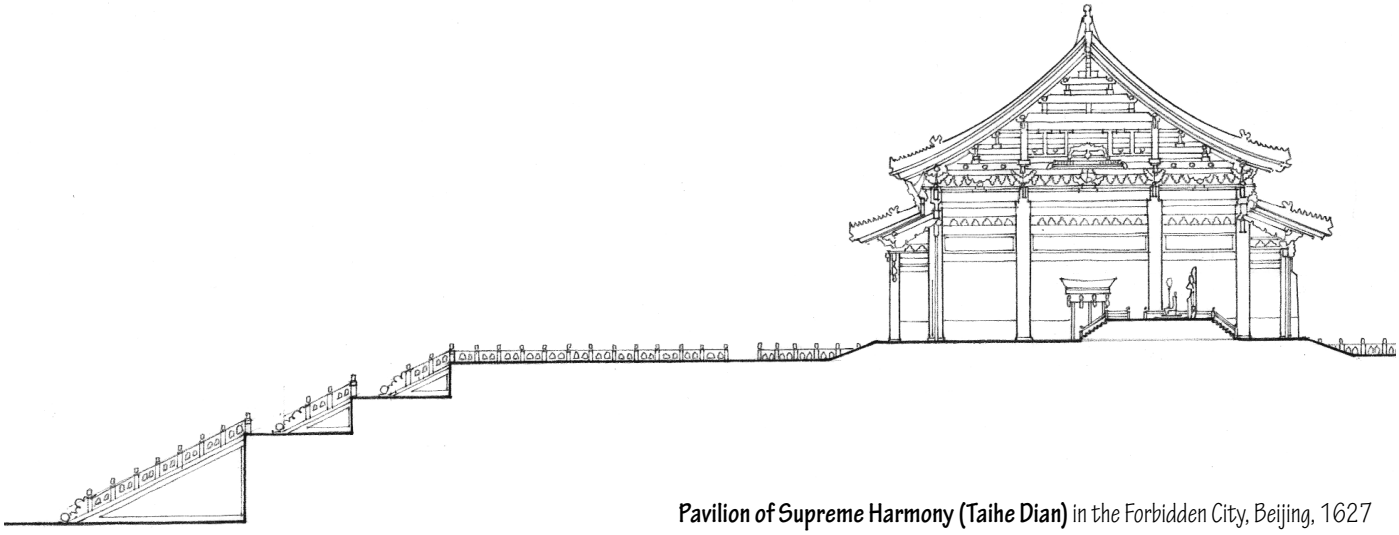
Izumo Shrine, Shimane Prefecture, Japan, A. D. 717 (last rebuilt in 1744)



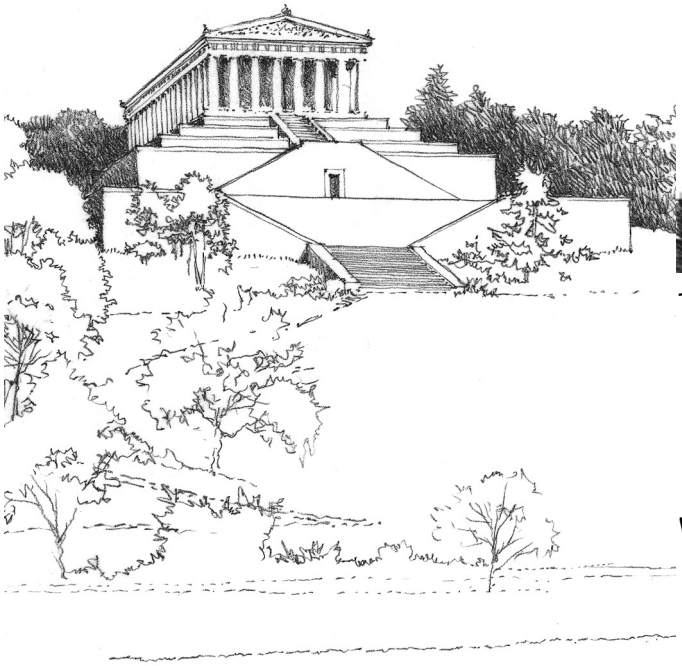
Temple of Jupiter Capitolinus, Rome, 509 B.C.

Elevating a portion of the ground plane establishes a platform or podium that structurally and visually supports the form and mass of a building. The elevated ground plane can be a preexisting site condition, or it can be artificially constructed to deliberately raise a building above the surrounding context or enhance its image in the landscape. The examples on this and the preceding page illustrate how these techniques have been used to venerate sacred and honorific buildings.





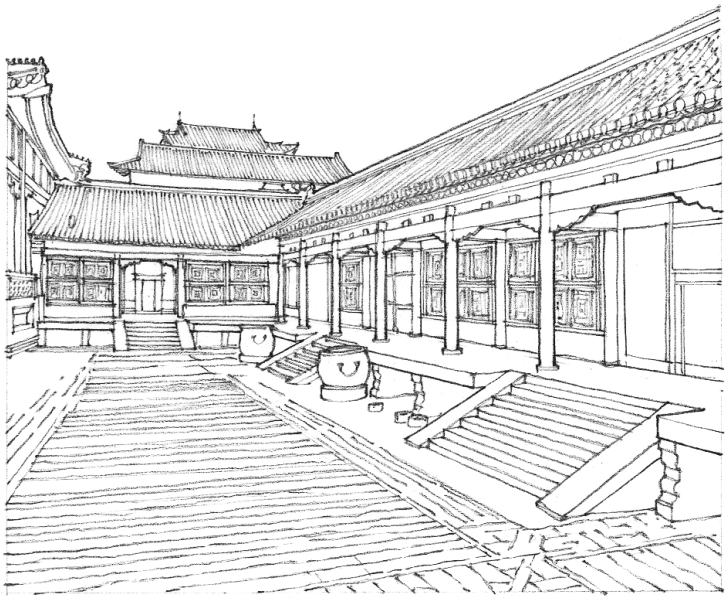
Pavilion of Supreme Harmony (Taihe Dian) in the Forbidden City, Beijing, 1627



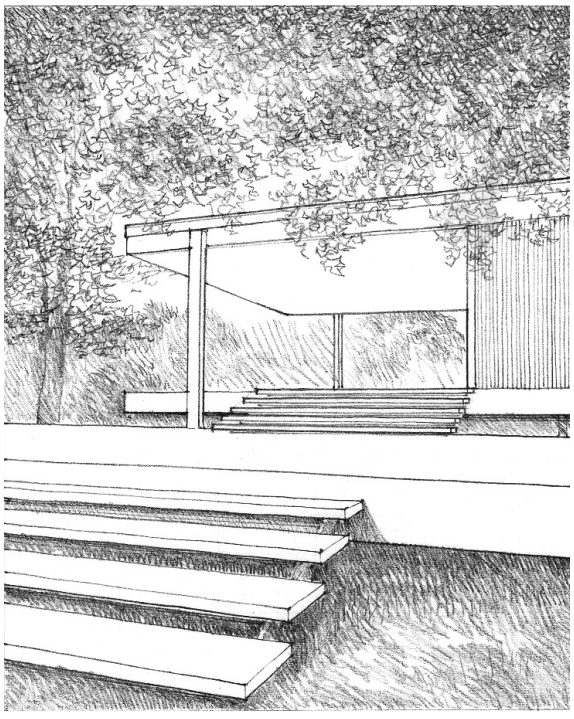
Temple Mountain, Bakong Temple, A.D. 881, Hariharalaya, Cambodia

Valhalla, near Regensburg, Germany, Leon von Klenze, 1830–1842

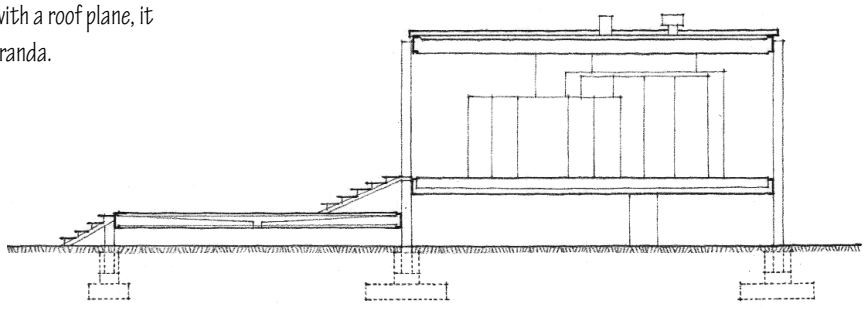
ELEVATED BASE PLANE



Private courtyard of the **Imperial Palace**, **the Forbidden City**, Beijing, China, 15th century

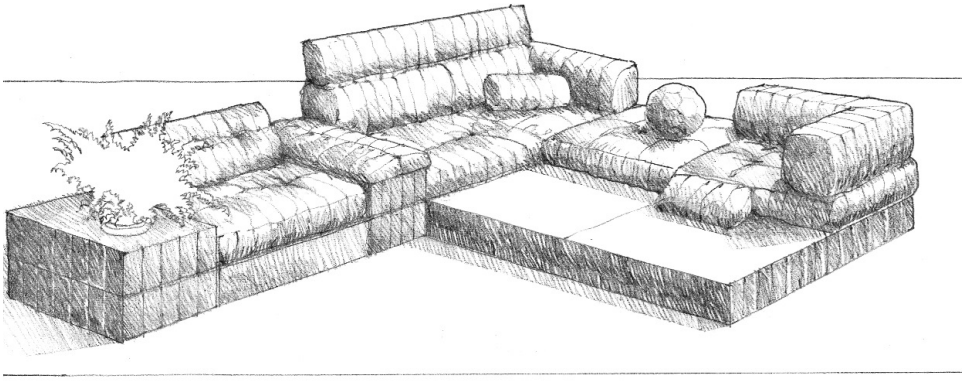


An elevated plane can define a transitional space between the interior of a building and the outdoor environment. Combined with a roof plane, it develops into the semiprivate realm of a porch or veranda.

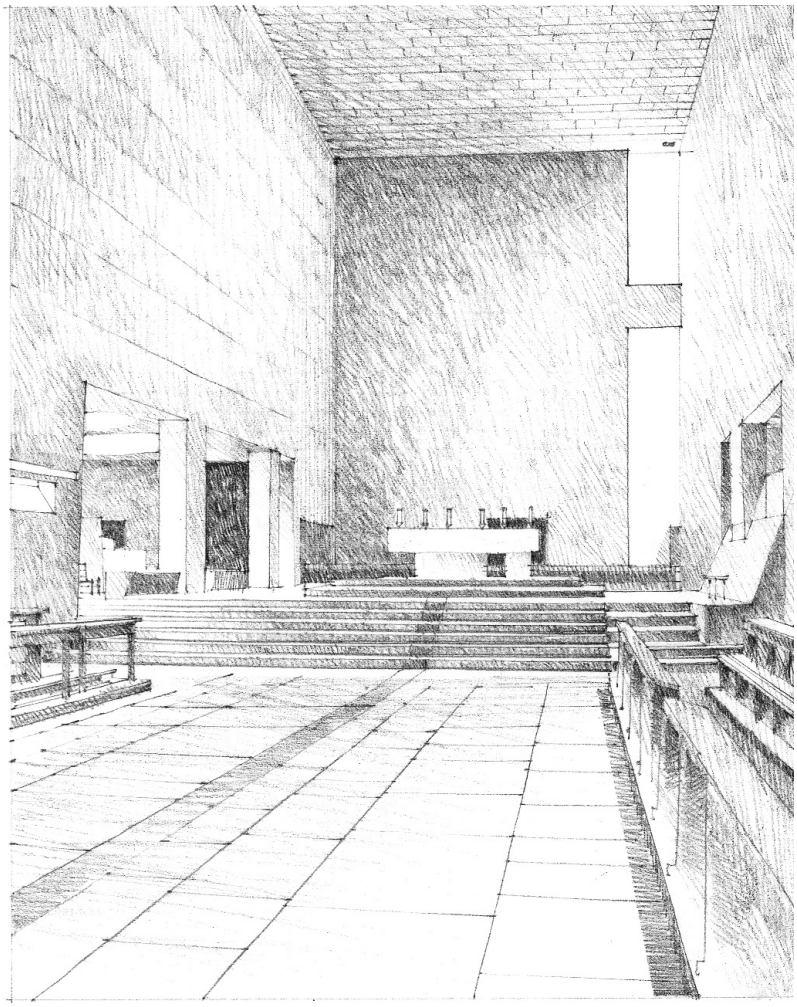


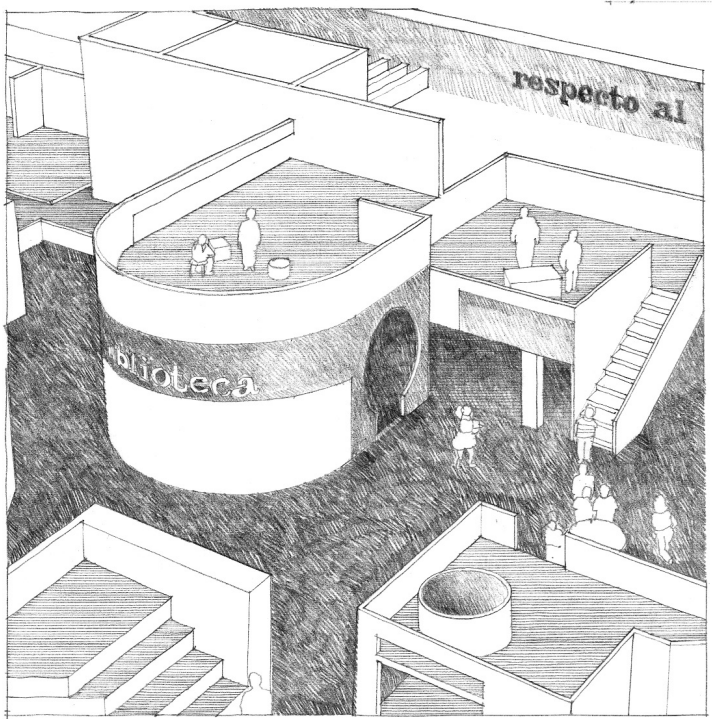
Section

Farnsworth House, Plano, Illinois, 1950, Mies van der Rohe.
The Farnsworth House was constructed to rise above the flood plain of the Fox River. This elevated floor plane, together with an overhead roof plane, defines a volume of space that hovers delicately above the surface of its site.



High Altar in the Chapel at the **Cistercian Monastery of La Tourette**, near Lyons, France, 1956–1959, Le Corbusier

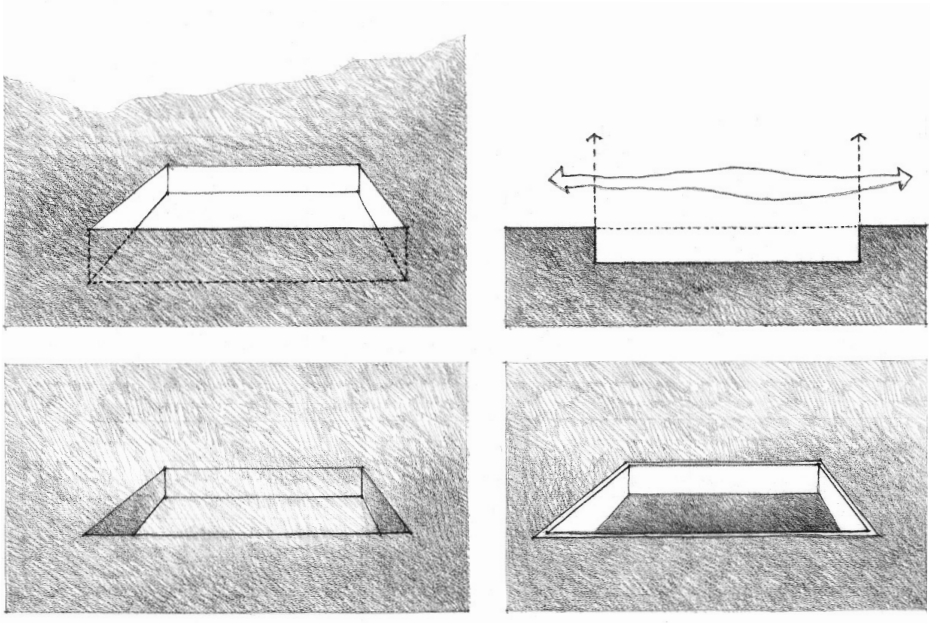




A section of the floor plane can be elevated to establish a singular zone of space within a larger room or hall. This raised space can serve as a retreat from the activity around it or be a platform for viewing the surrounding space. Within a religious structure, it can demarcate a sacred, holy, or consecrated place.

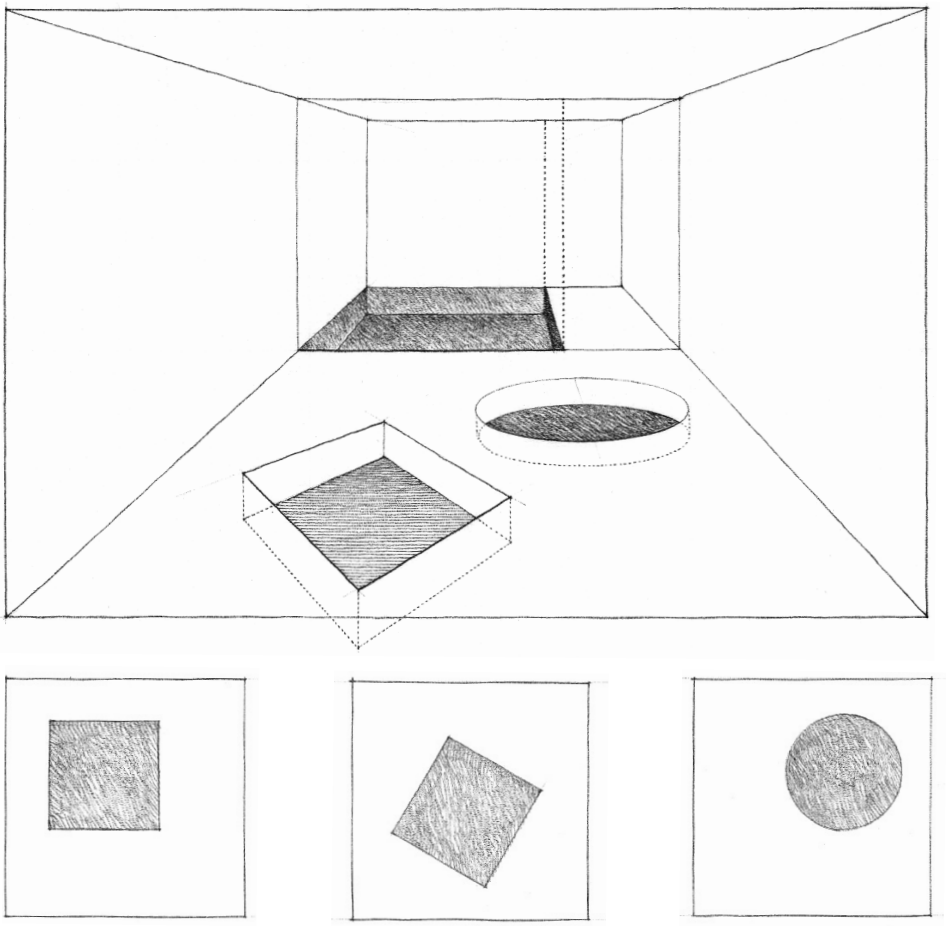
East Harlem Preschool, New York City, 1970, Hammel, Green & Abrahamson

DEPRESSED BASE PLANE



Lowering a portion of the base plane isolates a field of space from a larger context. The vertical surfaces of the depression establish the boundaries of the field. These boundaries are not implied as in the case of an elevated plane, but visible edges that begin to form the walls of the space.

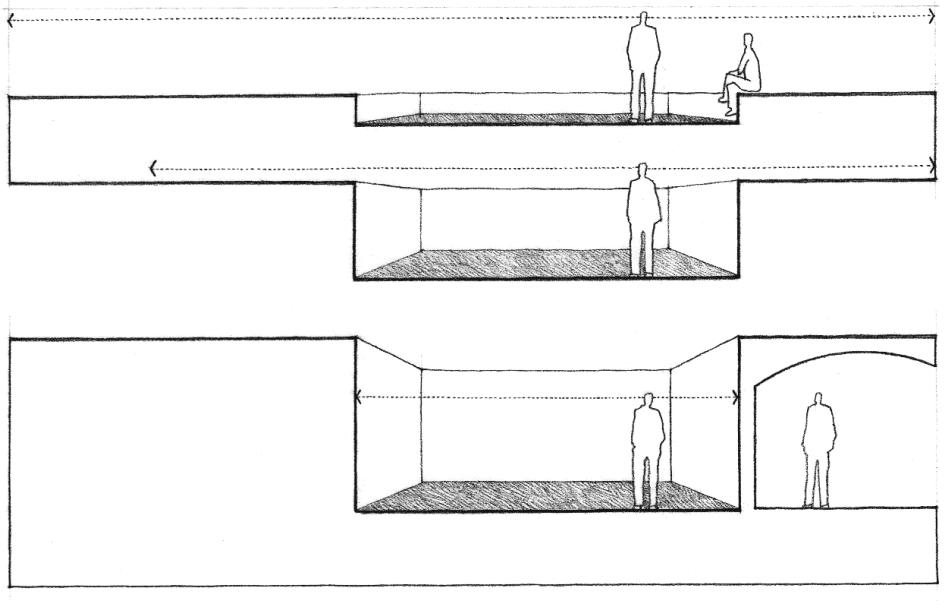
The field of space can be further articulated by contrasting the surface treatment of the lowered area and that of the surrounding base plane.



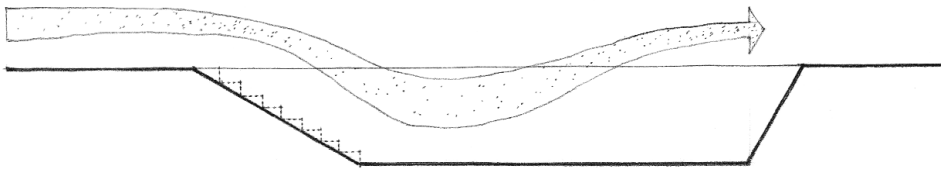
A contrast in form, geometry, or orientation can also visually reinforce the identity and independence of the sunken field from its larger spatial context.

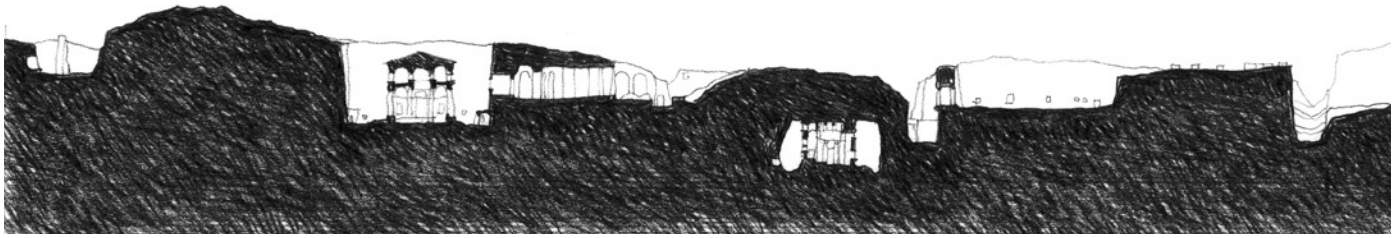
The degree of spatial continuity between a depressed field and the raised area surrounding it depends on the scale of the level change.

- The depressed field can be an interruption of the ground or floor plane and remain an integral part of the surrounding space.
- Increasing the depth of the depressed field weakens its visual relationship with the surrounding space and strengthens its definition as a distinct volume of space.
- Once the original base plane is above our eye level, the depressed field becomes a separate and distinct room in itself.



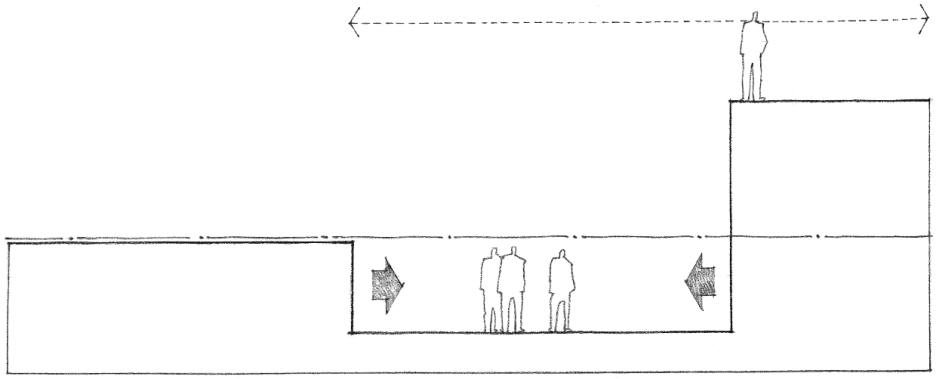
Creating a stepped, terraced, or ramped transition from one level to the next helps promote continuity between a sunken space and the area that rises around it.



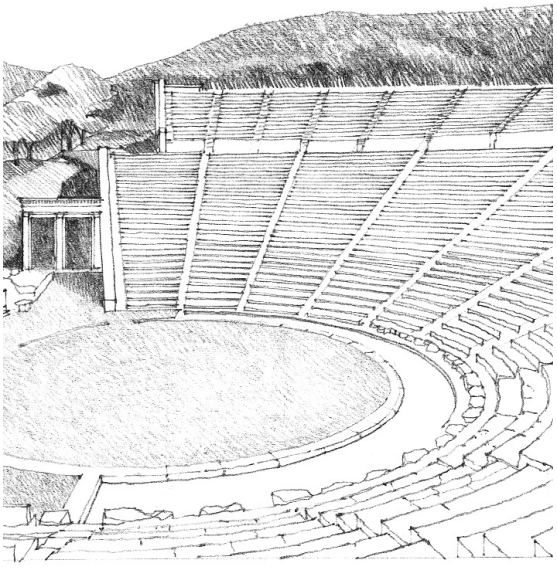


Rock-cut churches of Lalibela, 13th century

Whereas the act of stepping up to an elevated space might express the extroverted nature or significance of the space, the lowering of a space below its surroundings might allude to its introverted nature or to its sheltering and protective qualities.

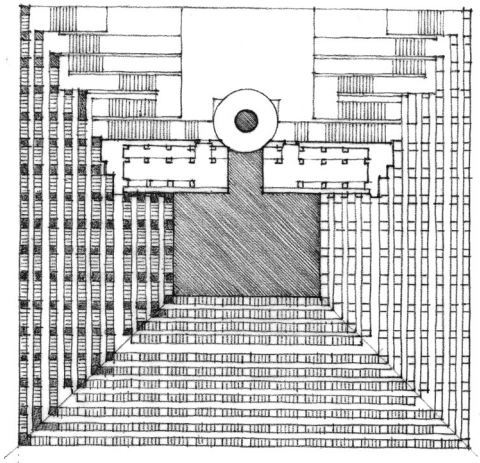


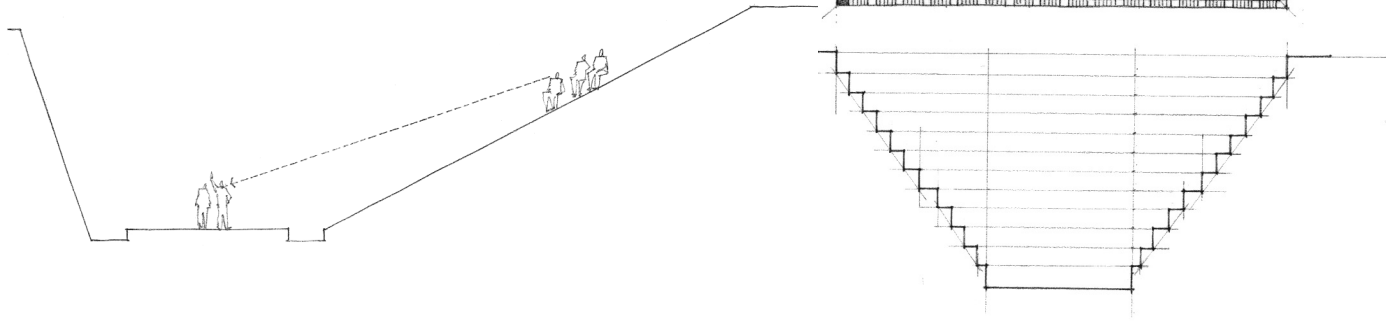
DEPRESSED BASE PLANE



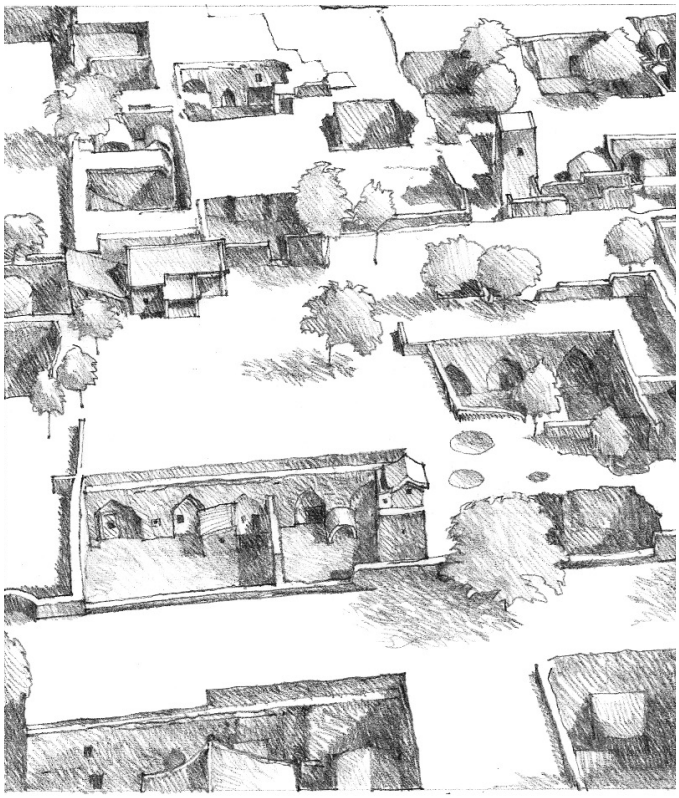
Theater at Epidauros, *Greece, c. 350 B.C., Polycleitos*

Depressed areas in the topography of a site can serve as stages for outdoor arenas and amphitheaters. The natural change in level benefits both the sightlines and the acoustical quality of these spaces.

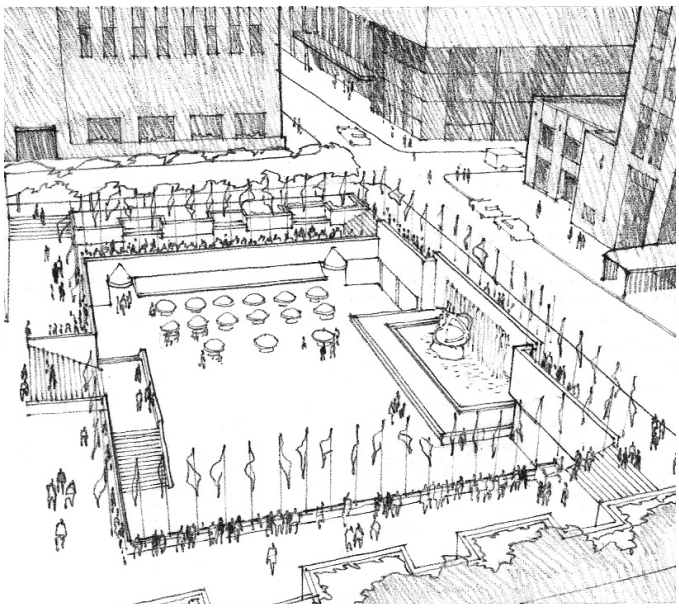




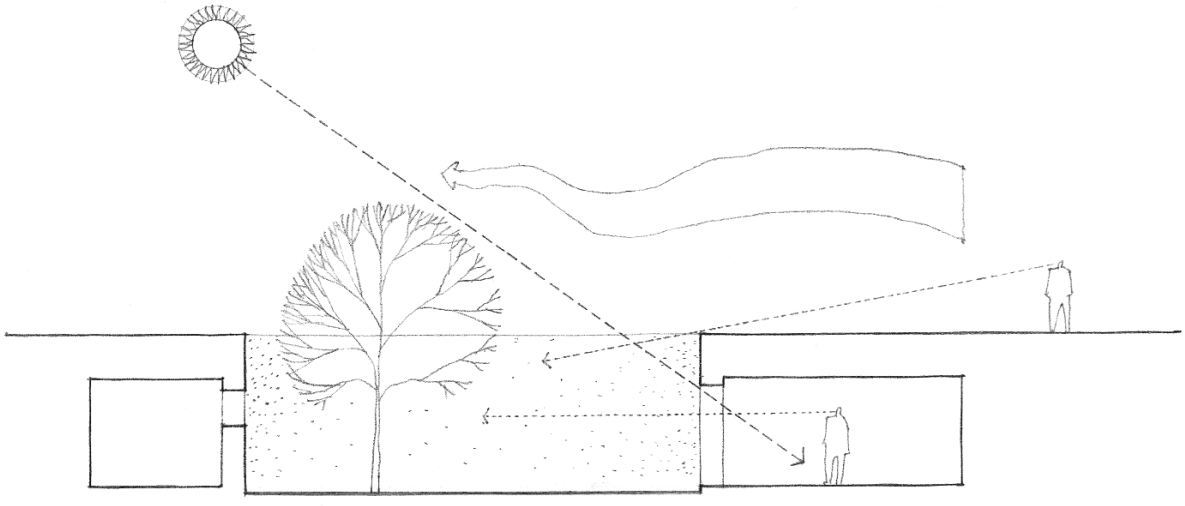
Step well at Abhaneri, *near Agra, India, 9th century*



Underground village near Loyang, China



Lower Plaza, **Rockefeller Center**, New York City, 1930, Wallace K. Harrison & Max Abramovitz. Rockefeller Center's lower plaza, an outdoor cafe in the summertime and a skating rink in the winter, can be viewed from the upper plaza while shops open onto it at the lower level.

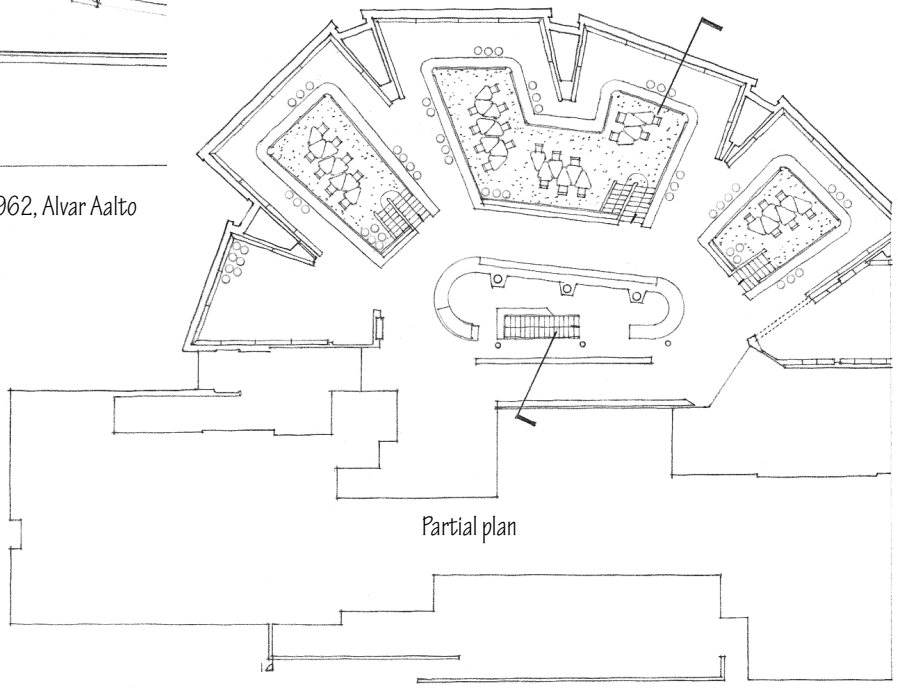


The ground plane can be lowered to define sheltered outdoor spaces for underground buildings. A sunken courtyard, while protected from surface-level wind and noise by the mass surrounding it, remains a source of air, light, and views for the underground spaces opening onto it.

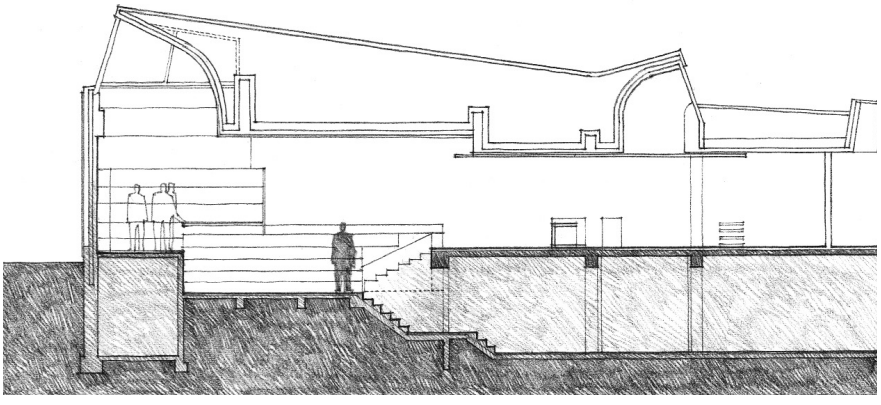
DEPRESSED BASE PLANE

In both of these examples, Alvar Aalto has defined a reading area within a larger library space by dropping its floor plane below the main level of the library. He then uses the vertical bounding surfaces of the reading area for additional book storage.

Library, Wolfsburg Cultural Center, Essen, Germany, 1962, Alvar Aalto

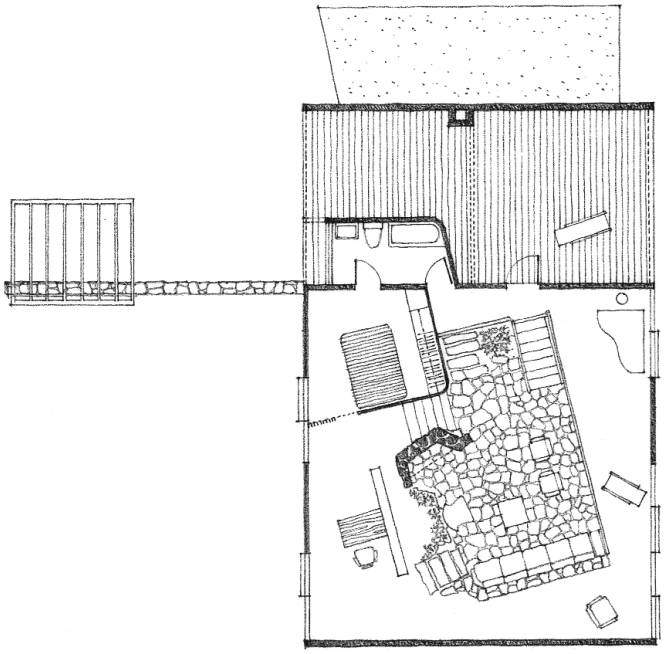


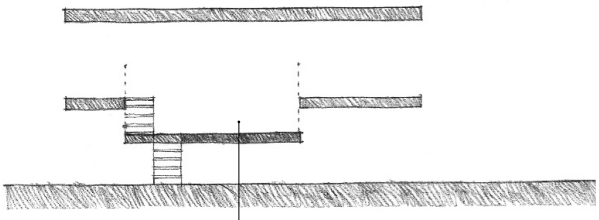
Partial plan



Library in Rovaniemi, Finland, 1965–1968, Alvar Aalto

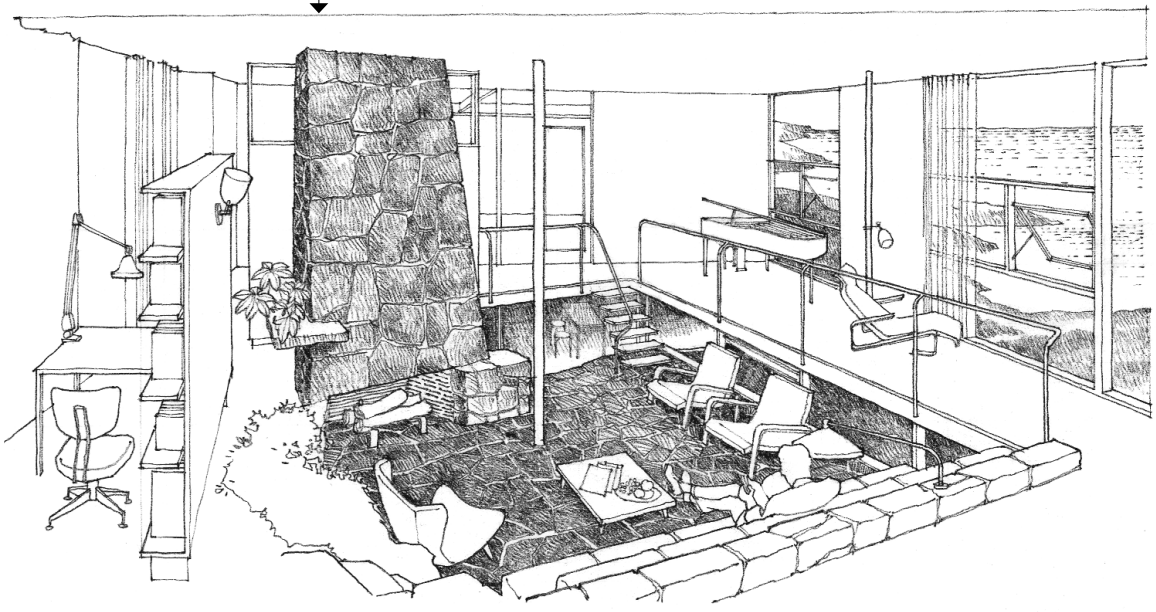
Partial section through the main reading room





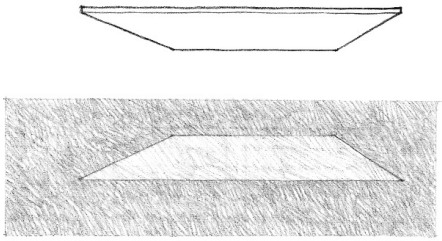
House on the Massachusetts Coast, 1948, Hugh Stubbins

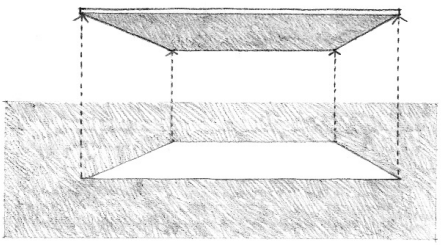
An area within a large room can be sunken to reduce the scale of the room and define a more intimate space within it. A sunken area can also serve as a transitional space between two floors of a building.



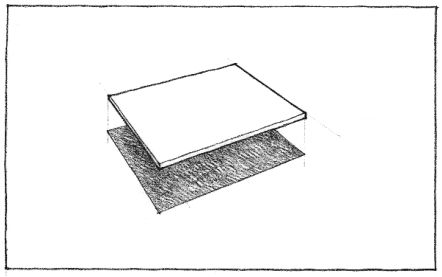
View of the lowered living level

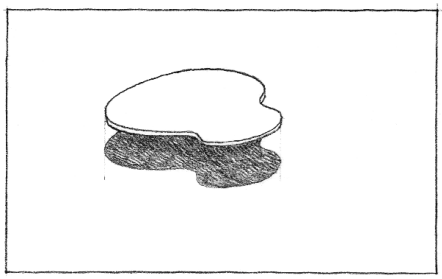
OVERHEAD PLANE



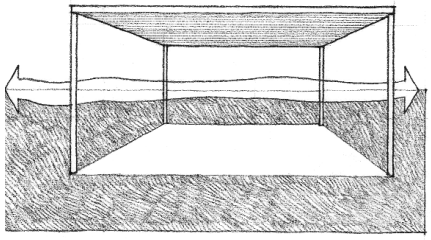


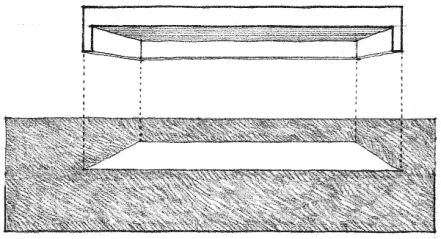
Similar to the manner in which a shade tree offers a sense of enclosure beneath its umbrella structure, an overhead plane defines a field of space between itself and the ground plane. Since the edges of the overhead plane establish the boundaries of this field, its shape, size, and height above the ground plane determines the formal qualities of the space.



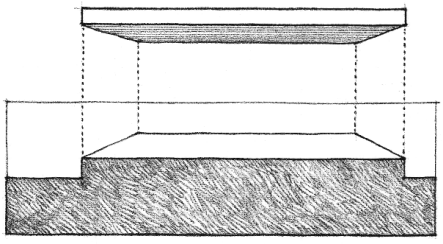


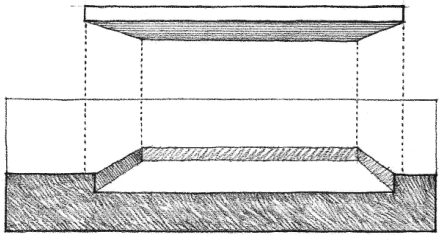
While the previous manipulations of the ground or floor plane defined fields of space whose upper limits were established by their context, an overhead plane has the ability to define a discrete volume of space virtually by itself.





If vertical linear elements such as columns or posts are used to support the overhead plane, they will aid in visually establishing the limits of the defined space without disrupting the flow of space through the field.

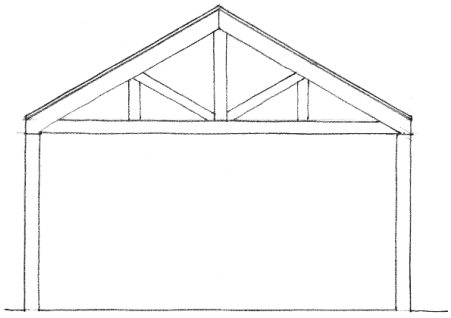




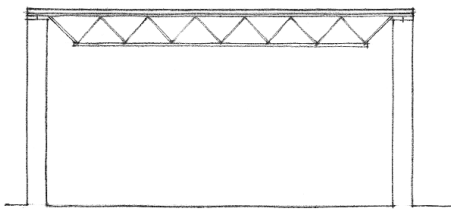
Similarly, if the edges of the overhead plane are turned downward, or if the base plane beneath it is articulated by a change in level, the boundaries of the defined volume of space will be visually reinforced.

Moving the roof of a house in Guinea

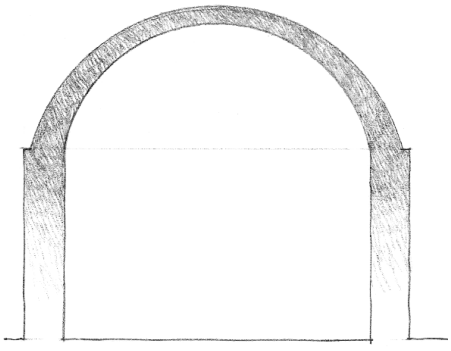
The major overhead element of a building is its roof plane. It not only shelters the interior spaces of a building from sun, rain, and snow, but also has a major impact on the overall form of a building and the shaping of its spaces. The form of the roof plane, in turn, is determined by the material, geometry, and proportions of its structural system and the manner in which it transfers its loads across space to its supports.



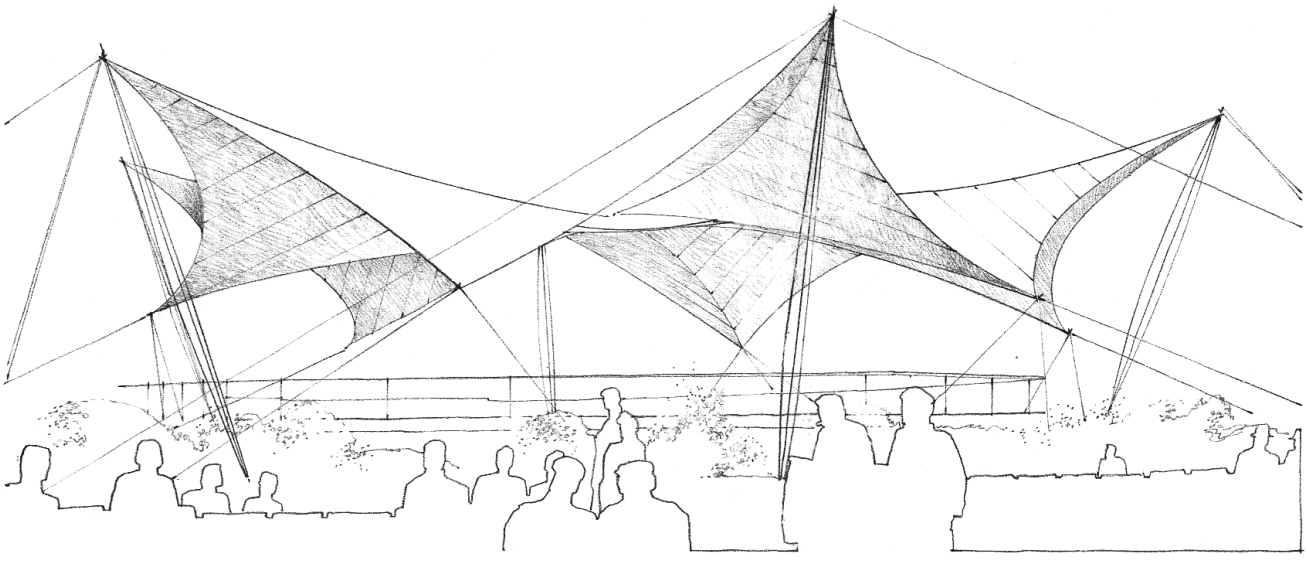
Wood Truss



Steel Joist

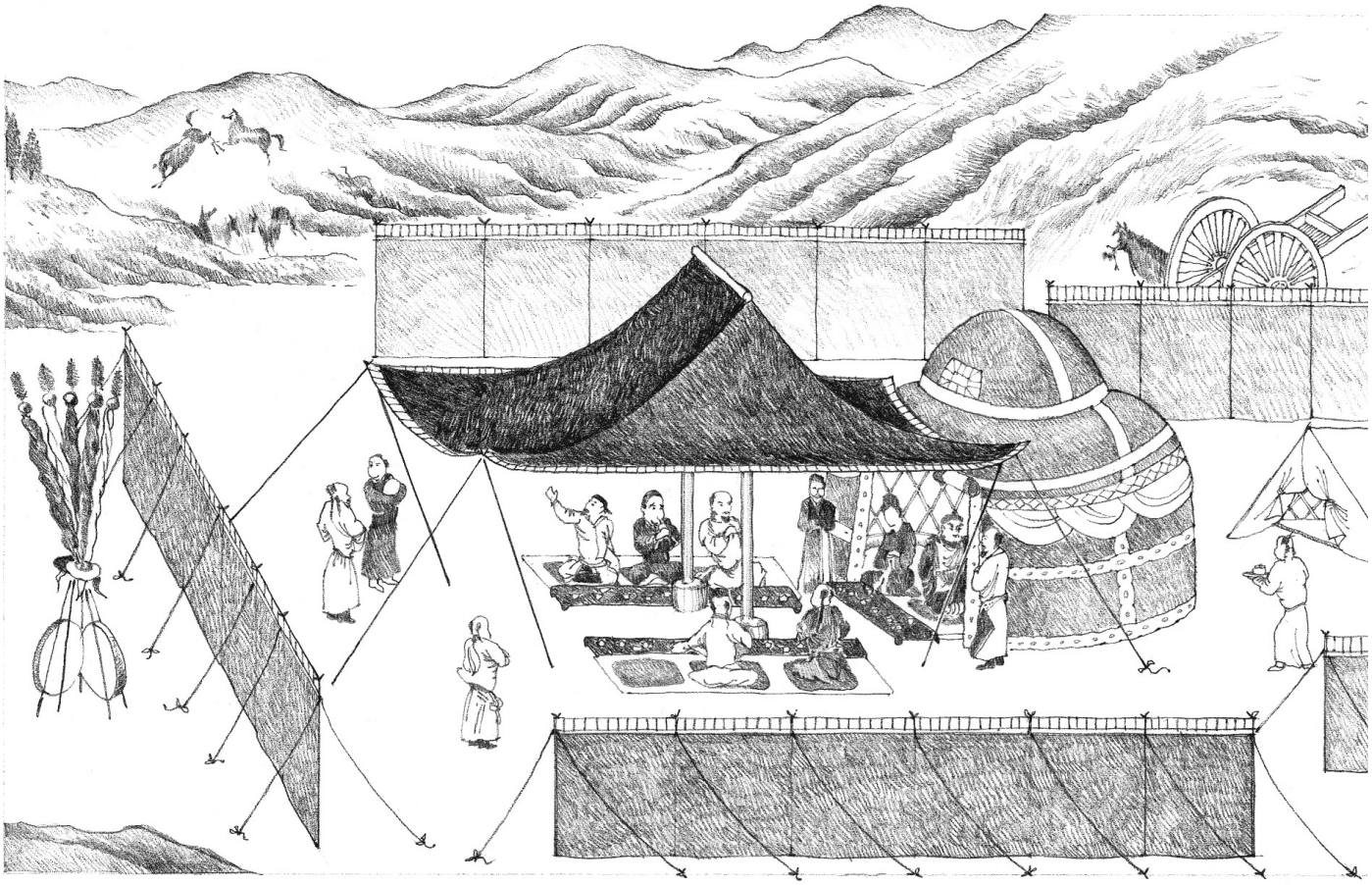


Masonry Vault

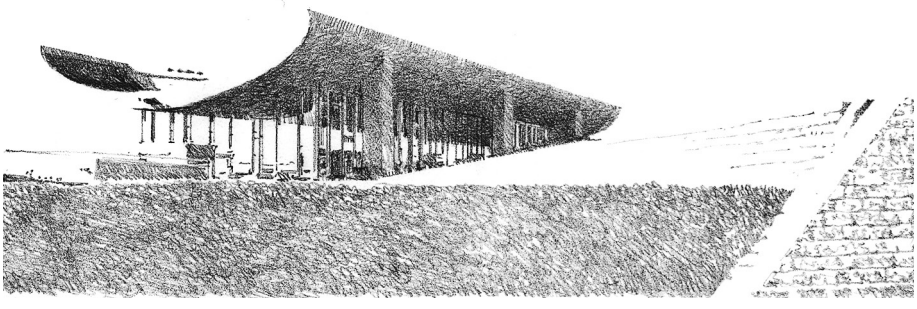


Tensile Structure, **National Garden Show**, Cologne, Germany, 1957, Frei Otto and Peter Stromeyer

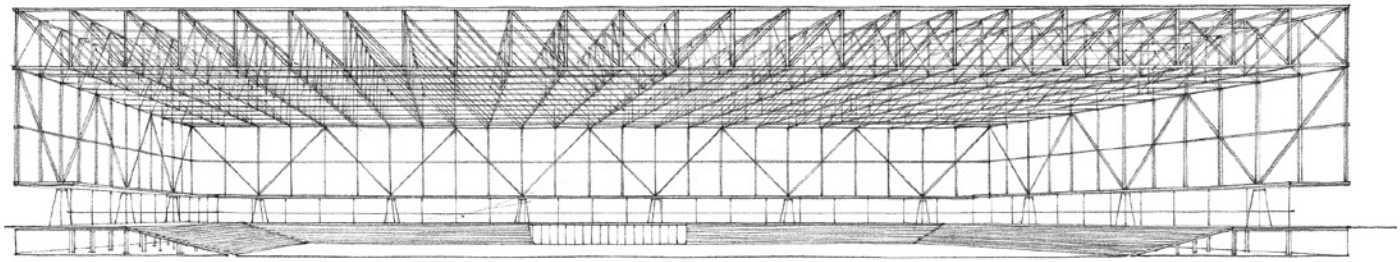
OVERHEAD PLANE



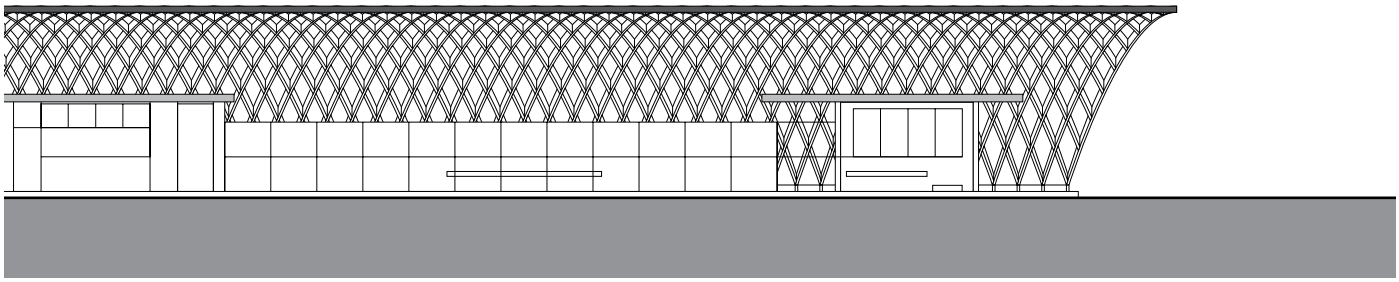
Scene illustrating the use of a pavilion structure to define a shaded resting place within an encampment. From the scroll painting *Eighteen Songs of a Nomad Flute: The Story of Lady Wenji* (early 15th century, artist unidentified).



Totsuka Country Club, Yokohama, Japan, Kenzo Tange, 1960–1961

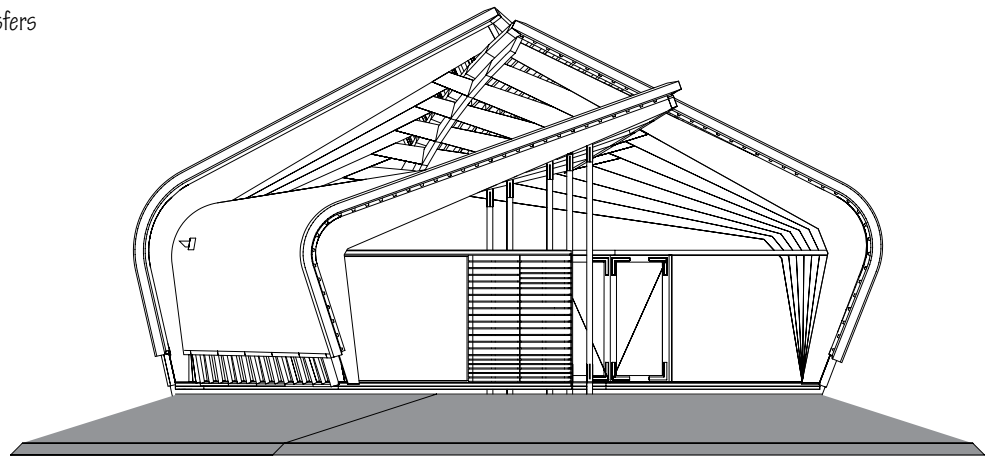


Convention Hall for Chicago (Project), 1953, Mies van der Rohe



Hale County Animal Shelter, Greensboro, Alabama, 2008, Rural Studio, Auburn University

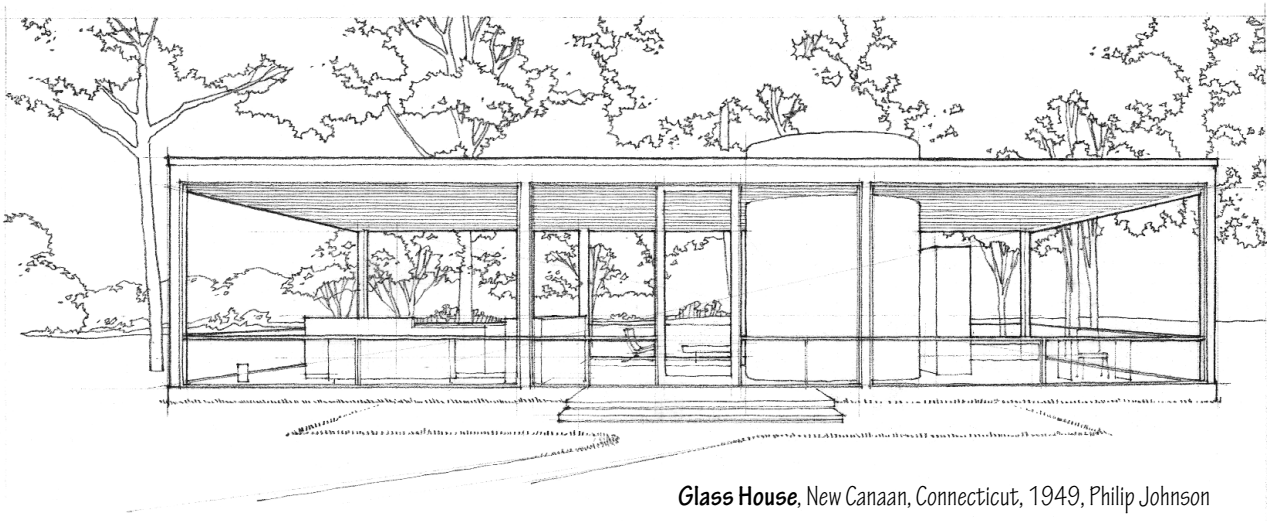
The roof plane can visually express how its pattern of structural members resolves forces and transfers loads to a system of supports.



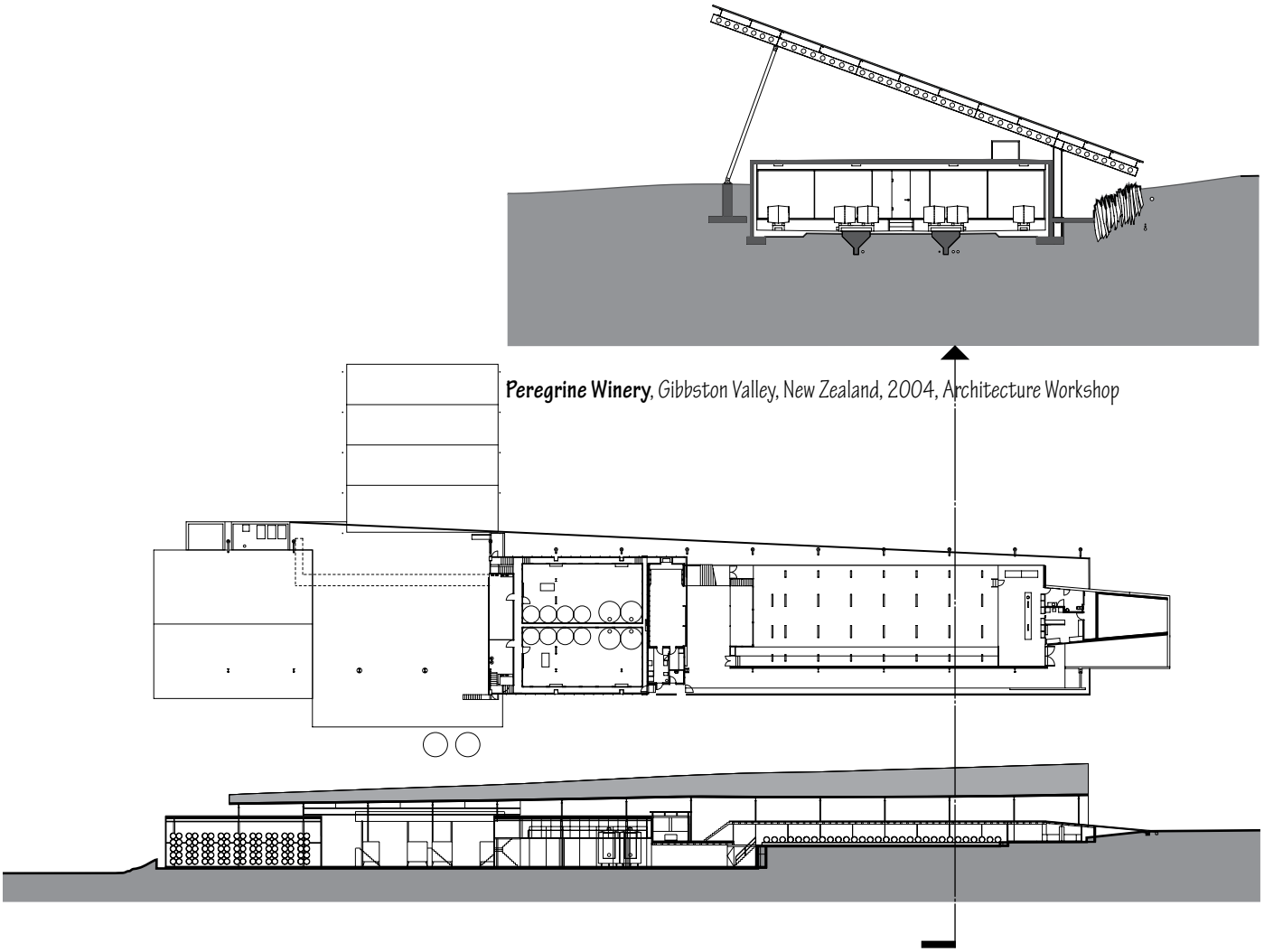
Imagination Art Pavilion, Zeewolde, The Netherlands, 2000, René van Zuuk

OVERHEAD PLANE

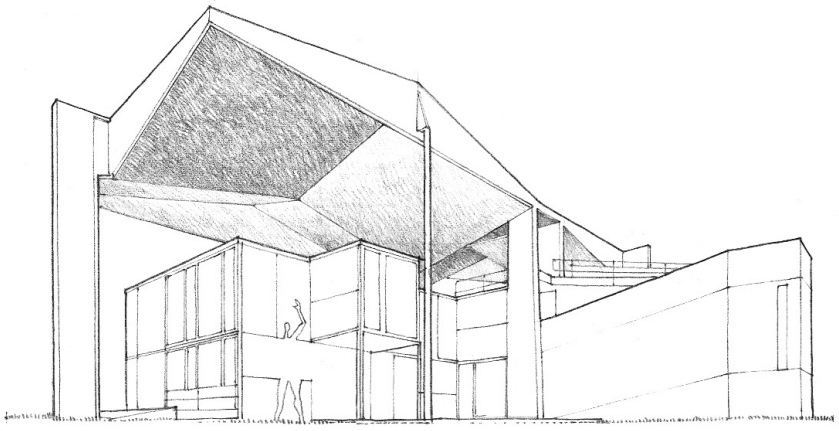
The roof plane can be the major space-defining element of a building and visually organize a series of forms and spaces beneath its sheltering canopy.



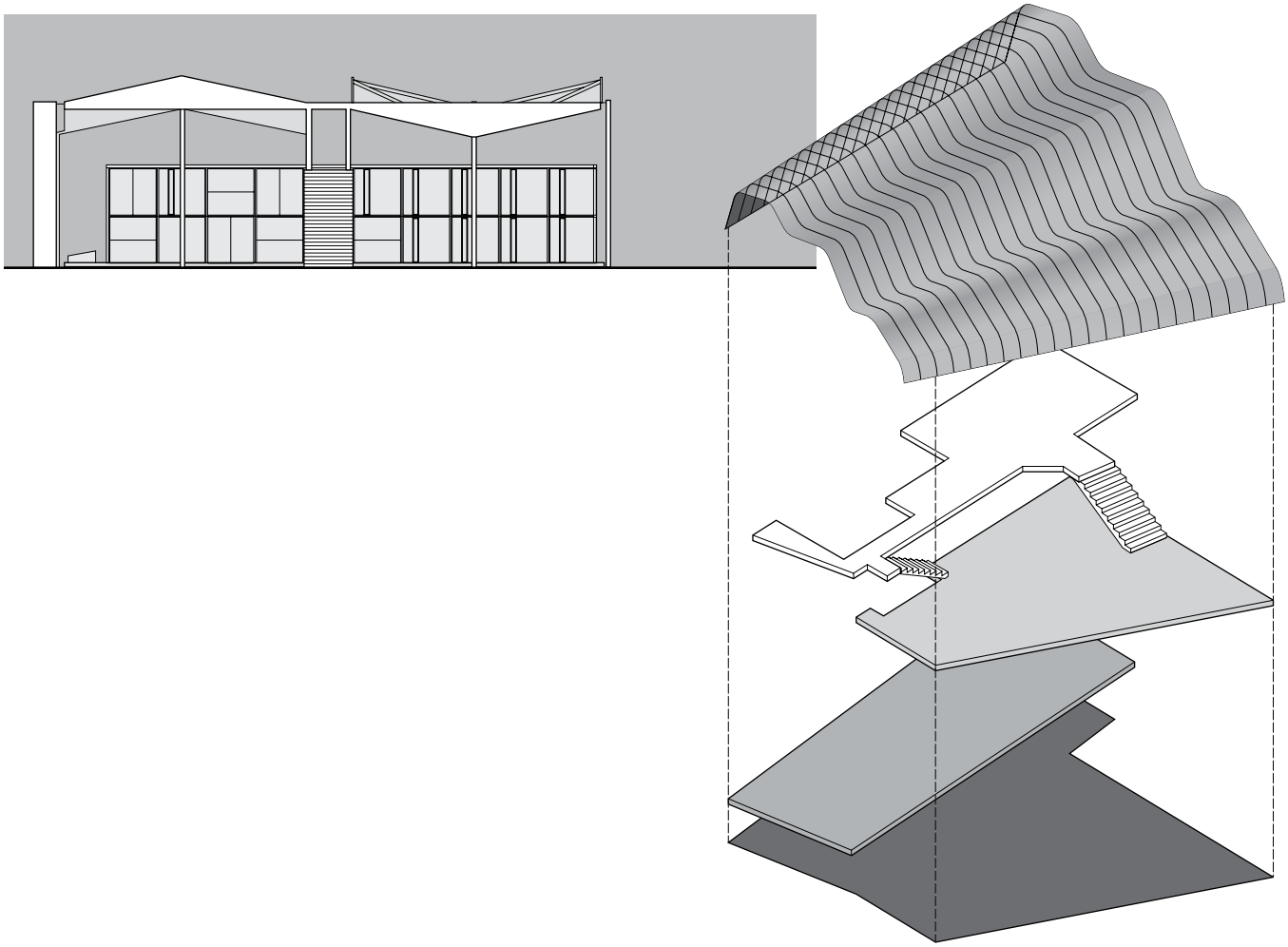
Glass House, New Canaan, Connecticut, 1949, Philip Johnson



Peregrine Winery, Gibbston Valley, New Zealand, 2004, Architecture Workshop



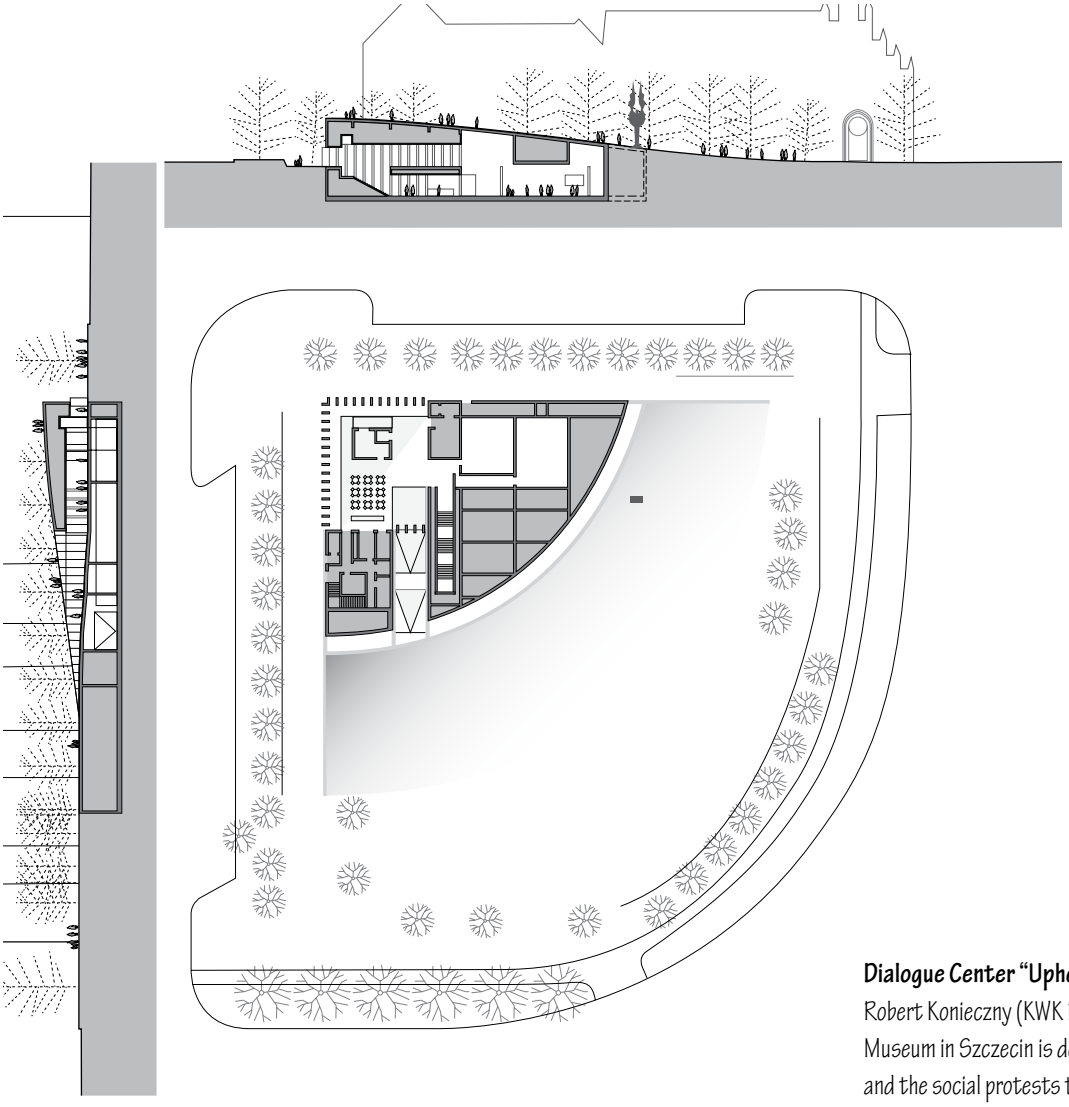
Centre Le Corbusier, Zurich, 1963–1967, *Le Corbusier*



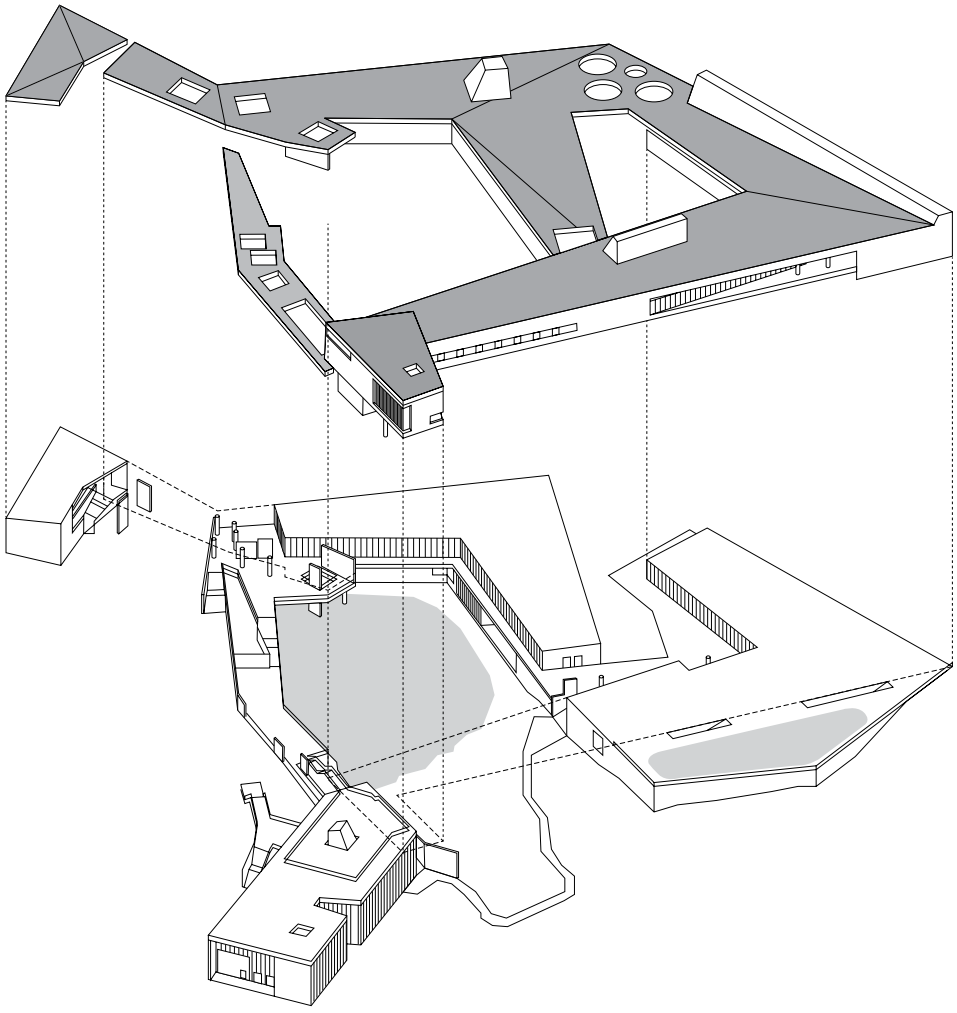
Jasper Place Branch Library, Edmonton, Canada, 2013, *Hughes Condon Marier Architects + Dub Architects*

OVERHEAD PLANE

While the overhead roof plane serves to define and shelter the interior spaces of a building, it can also be designed and constructed to serve as a new ground plane.



Dialogue Center "Upheavals," Szczecin, Poland, 2016, Robert Konieczny (KWK Promes). This branch of the National Museum in Szczecin is dedicated to the history of Szczecin and the social protests that helped lead Poland to regain independence in 1989. The museum is hidden partly underground to allow its roof and Solidarity Square to remain an open city space.

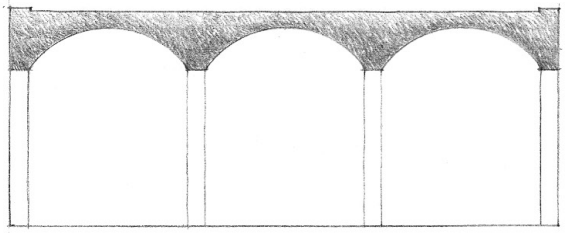


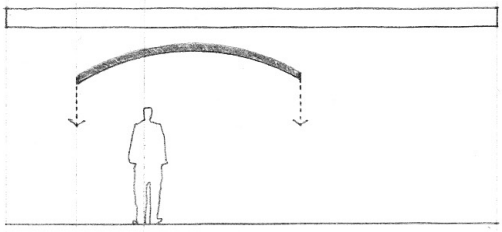
Chongqing Taoyuanju Community Center, Chongqing, China. 2015, Vector Architects. A green roof connects the three separate structures of the community center to the surrounding landscape of the site, which is set in the mountains of Taoyuan Park.

Potential benefits of green or vegetated roofs include:

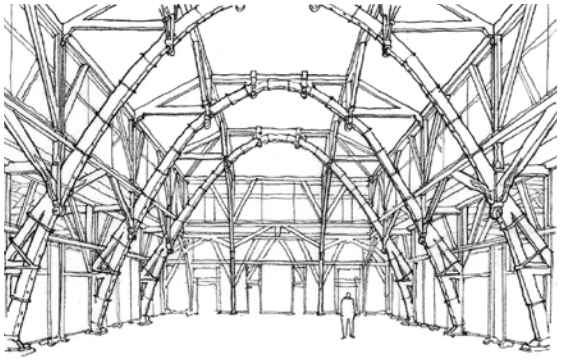
- Reduce the urban heat island effect by covering roofing surfaces with vegetation that absorbs less heat.
- Control stormwater runoff and retention.
- Increase the thermal insulation value of the roof plane.
- Provide accessible urban green spaces.
- Incorporate urban agriculture of herbs and vegetables.
- Provide a refuge for insects and birds that have lost their natural habitat due to urban development.

OVERHEAD PLANE

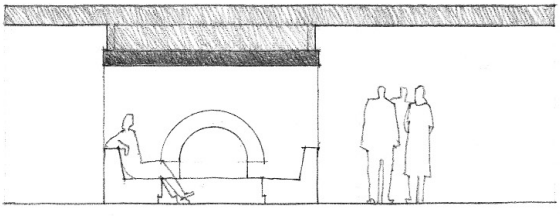


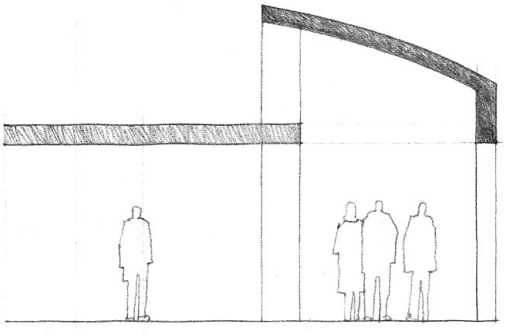


The ceiling plane of an interior space can reflect the form of the structural system supporting the overhead floor or roof plane. Since it need not resist any weathering forces nor carry any major loads, the ceiling plane can also be detached from the floor or roof plane and become a visually active element in a space.

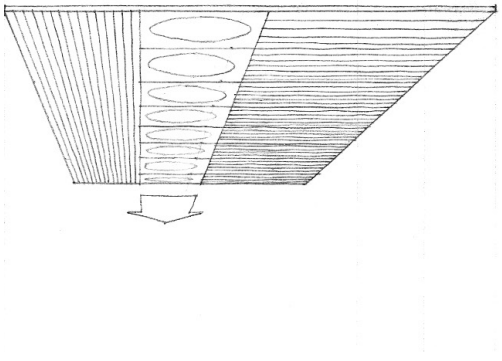


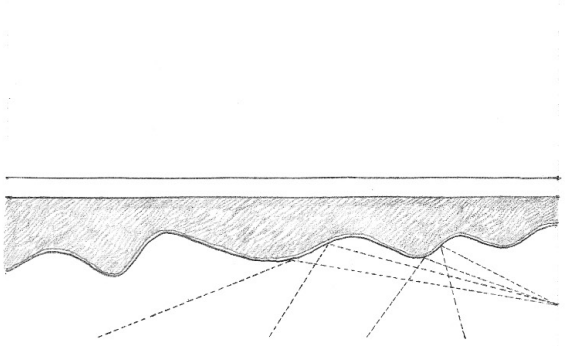
Bandung Institute of Technology, Bandung, Indonesia, 1920, Henri Maclaine Pont





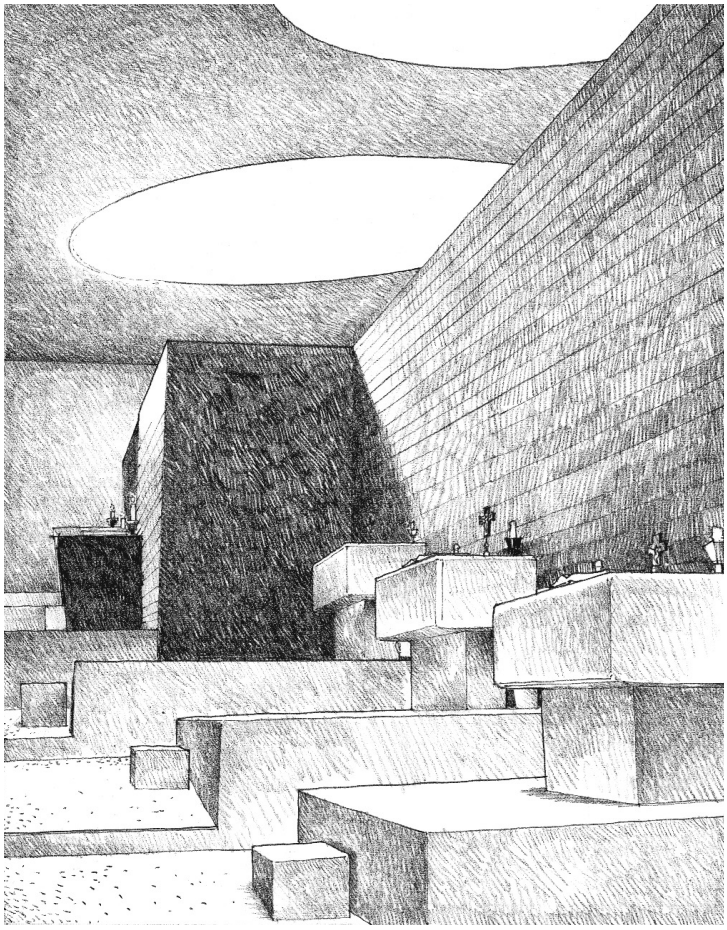
As in the case of the base plane, the ceiling plane can be manipulated to define and articulate zones of space within a room. It can be lowered or elevated to alter the scale of a space, define a path of movement through it, or allow natural light to enter it from above.



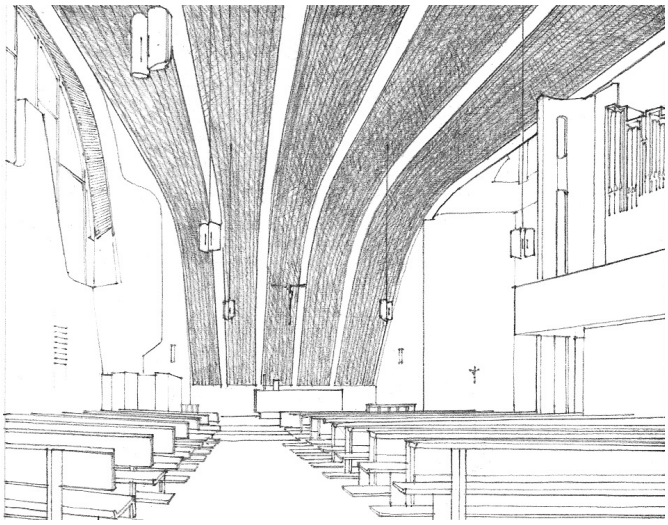


The form, color, texture, and pattern of the ceiling plane can be manipulated as well to improve the quality of light or sound within a space or give it a directional quality or orientation.

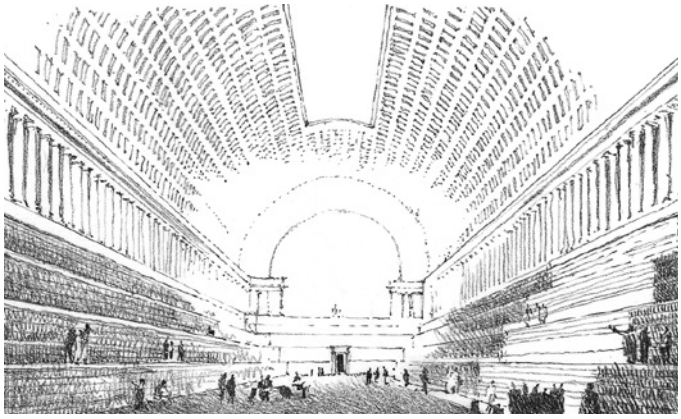
Side Chapels, **Cistercian Monastery of La Tourette**, near Lyons, France, 1956–1959, Le Corbusier



Well-defined negative areas or voids within an overhead plane, such as for skylights, can be seen as positive shapes that establish the presence of spatial fields below their openings.

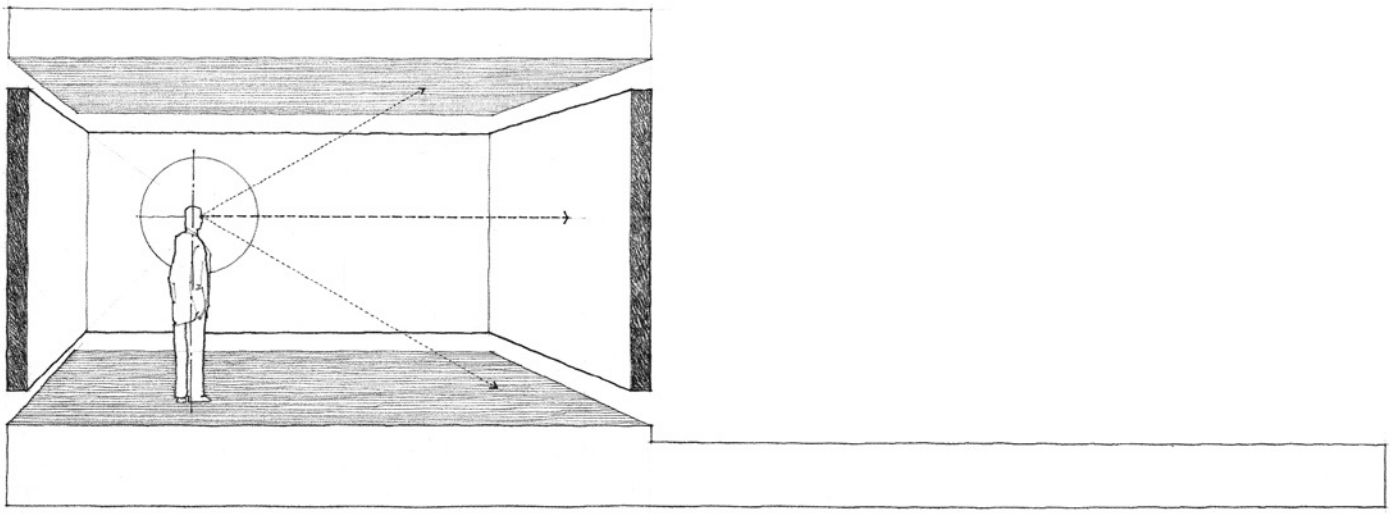


Parish Center, Wolfsburg, Germany, 1960–1962, Alvar Aalto



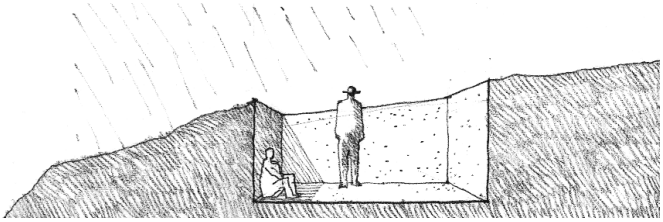
Bibliothèque Nationale (Project), 1788, Étienne-Louis Boullée

VERTICAL ELEMENTS DEFINING SPACE

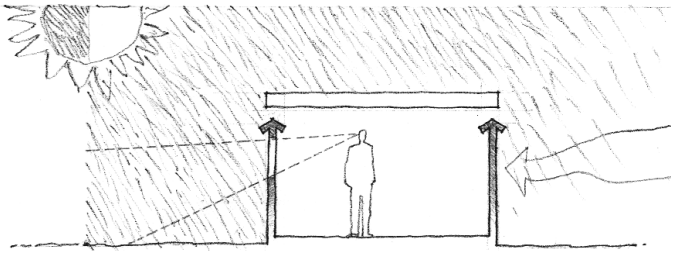


In the previous section of this chapter, horizontal planes defined fields of space in which the vertical boundaries were implied rather than explicitly described. The following section discusses the critical role vertical elements of form play in firmly establishing the visual limits of a spatial field.

Vertical forms have a greater presence in our visual field than horizontal planes and are therefore more instrumental in defining a discrete volume of space and providing a sense of enclosure and privacy for those within it. In addition, they serve to separate one space from another and establish a common boundary between the interior and exterior environments.

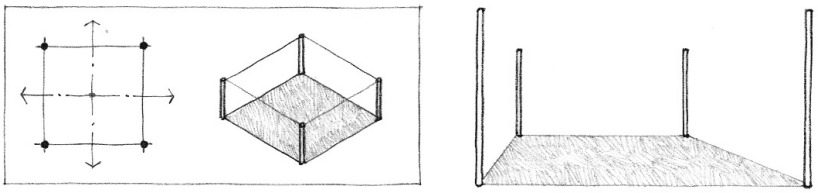


Vertical elements of form also play important roles in the construction of architectural forms and spaces. They serve as structural supports for floor and roof planes. They provide shelter and protection from the climatic elements and aid in controlling the flow of air, heat, and sound into and through the interior spaces of a building.



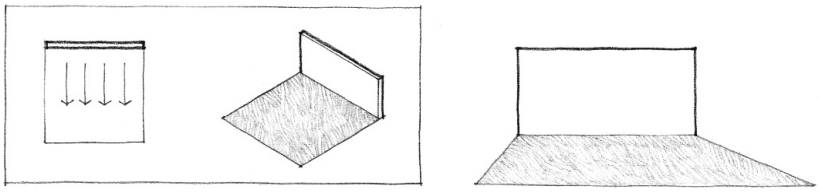
Vertical Linear Elements

Vertical linear elements define the perpendicular edges of a volume of space.



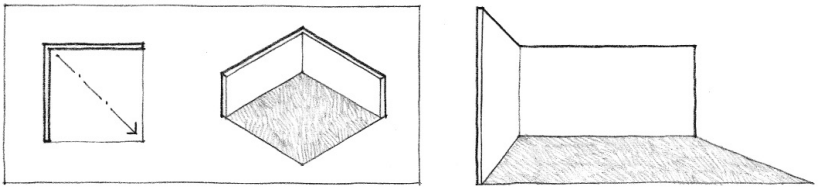
Single Vertical Plane

A single vertical plane articulates the space on which it fronts.



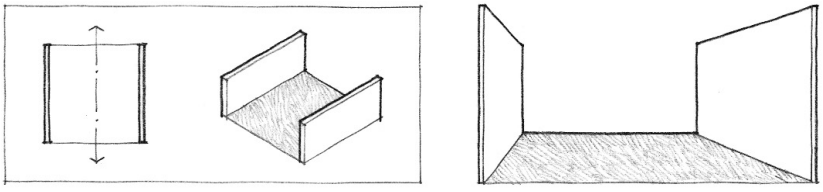
L-shaped Plane

An L-shaped configuration of vertical planes generates a field of space from its corner outward along a diagonal axis.



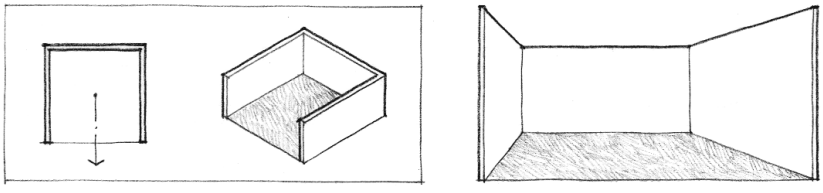
Parallel Planes

Two parallel vertical planes define a volume of space between them that is oriented axially toward both open ends of the configuration.



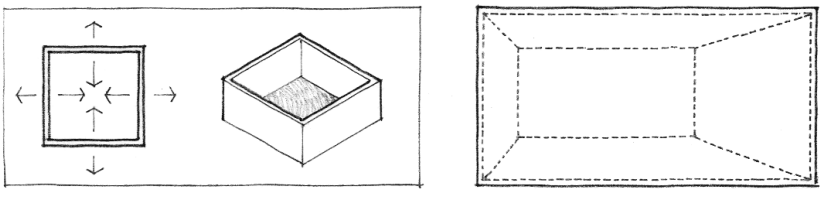
U-shaped Plane

A U-shaped configuration of vertical planes defines a volume of space that is oriented primarily toward the open end of the configuration.

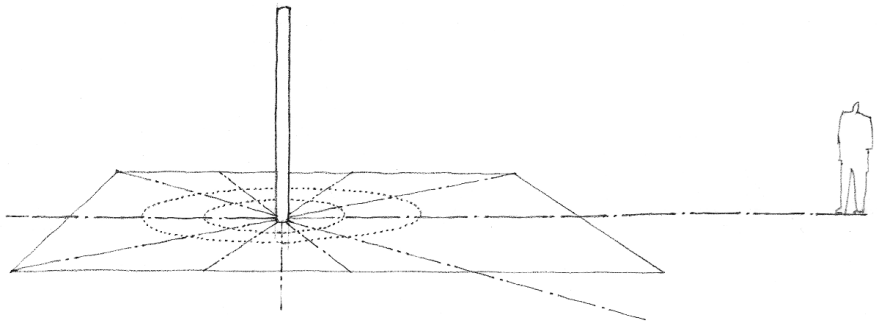


Four Planes: Closure

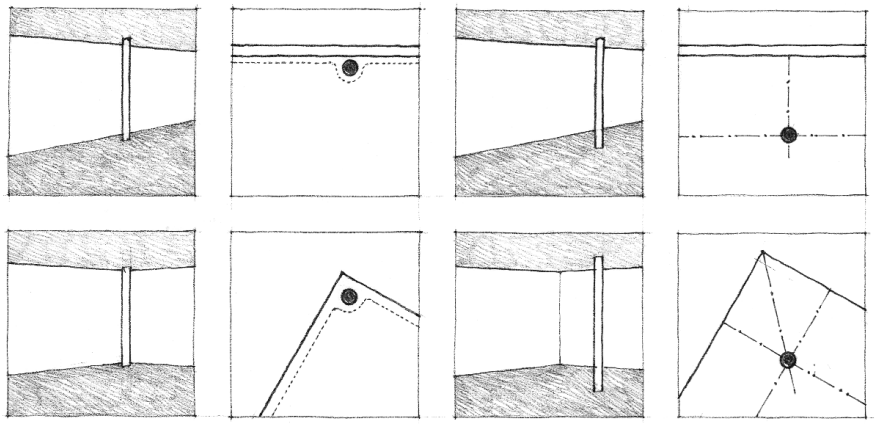
Four vertical planes establish the boundaries of an introverted space and influence the field of space around the enclosure.



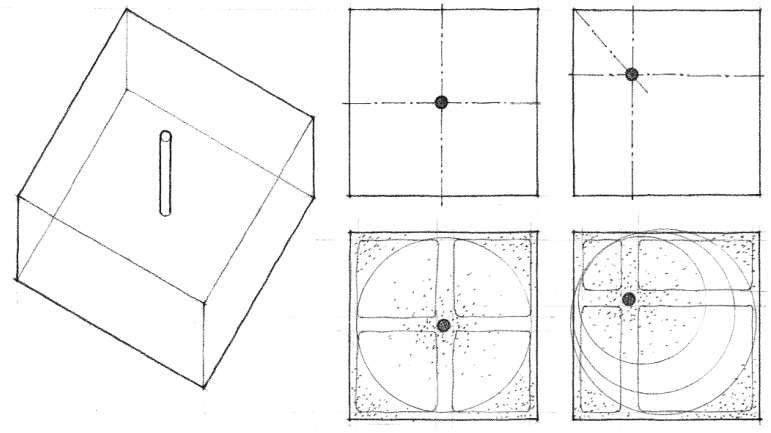
VERTICAL LINEAR ELEMENTS



A vertical linear element, such as a column, obelisk, or tower, establishes a point on the ground plane and makes it visible in space. Standing upright and alone, a slender linear element is nondirectional except for the path that would lead us to its position in space. Any number of horizontal axes can be made to pass through it.

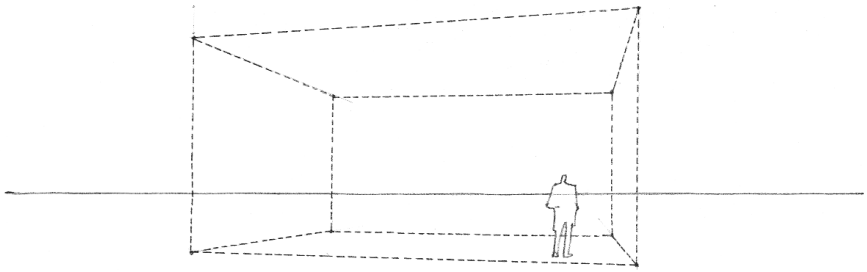


When located within a defined volume of space, a column will generate a spatial field about itself and interact with the spatial enclosure. A column attached to a wall buttresses the plane and articulates its surface. At the corner of a space, a column punctuates the meeting of two wall planes. Standing free within a space, a column defines zones of space within the enclosure.

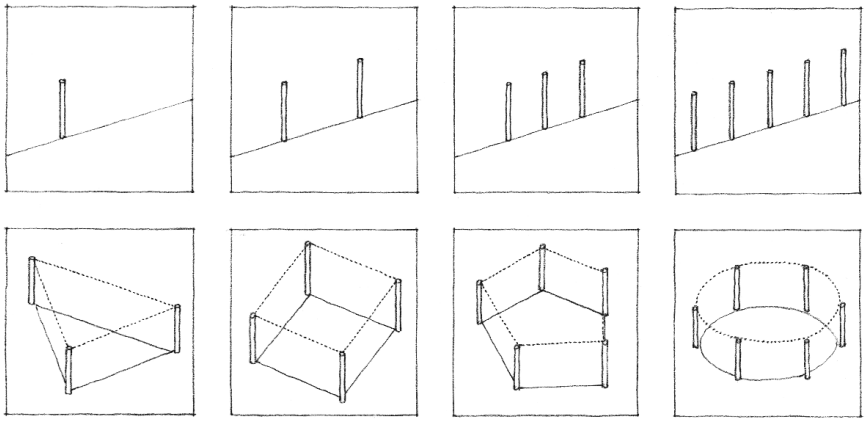


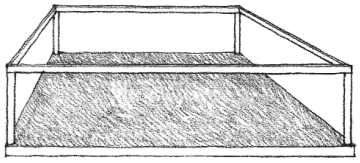
When centered in a space, a column will assert itself as the center of the field and define equivalent zones of space between itself and the surrounding wall planes. When offset, the column will define hierarchical zones of space differentiated by size, form, and location.

No volume of space can be established without the definition of its edges and corners. Linear elements serve this purpose in marking the limits of spaces that require visual and spatial continuity with their surroundings.

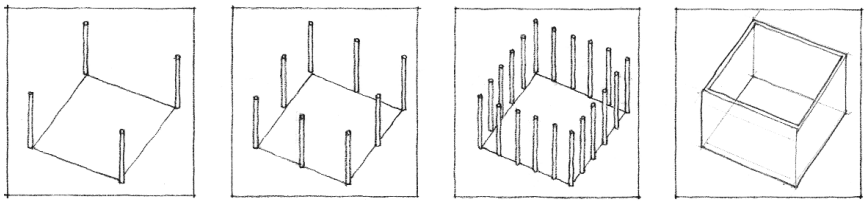


Two columns establish a transparent spatial membrane by the visual tension between their shafts. Three or more columns can be arranged to define the corners of a volume of space. This space does not require a larger spatial context for its definition, but relates freely to it.

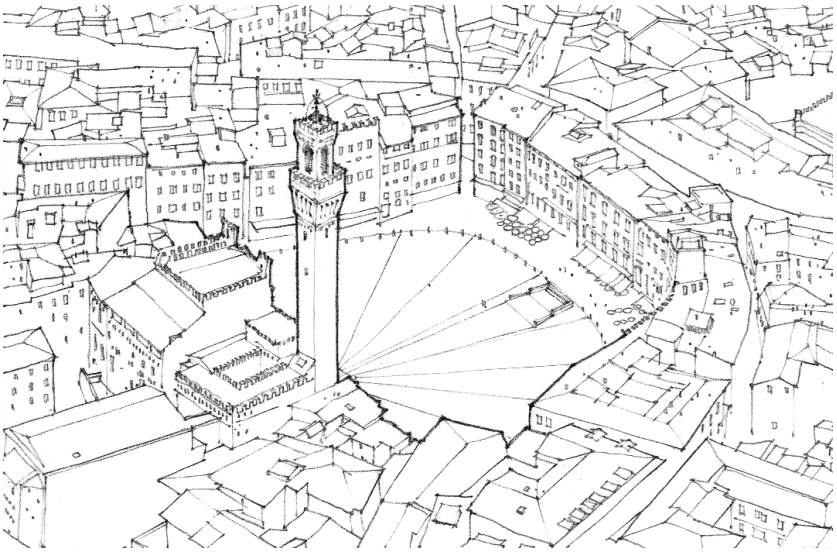




The edges of the volume of space can be visually reinforced by articulating its base plane and establishing its upper limits with beams spanning between the columns or with an overhead plane. A repetitive series of column elements along its perimeter would further strengthen the definition of the volume.

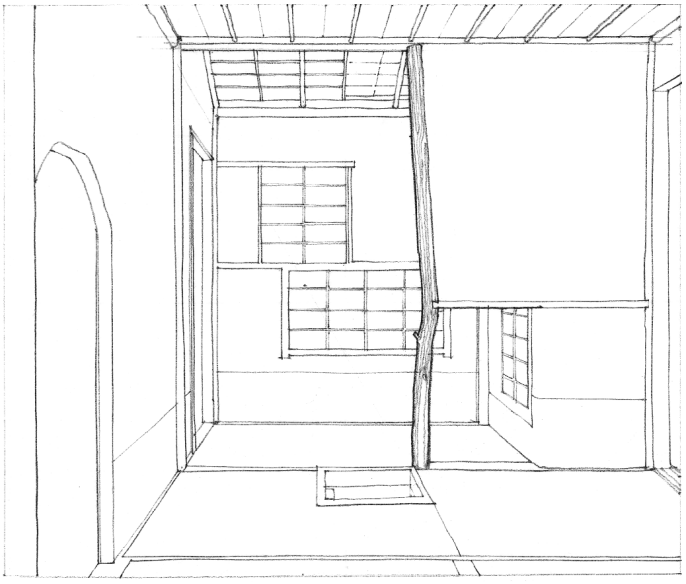


VERTICAL LINEAR ELEMENTS

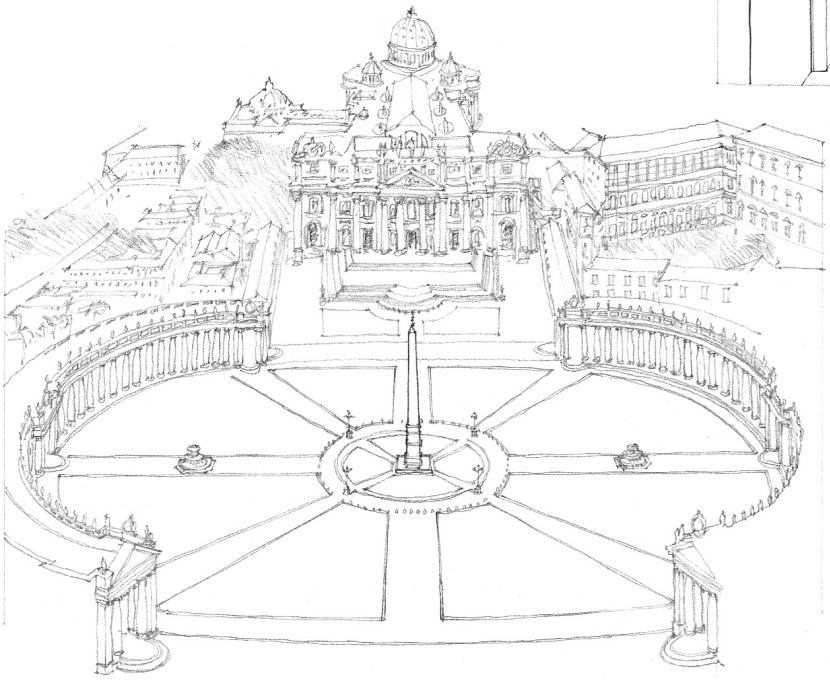


Piazza del Campo, Siena, Italy

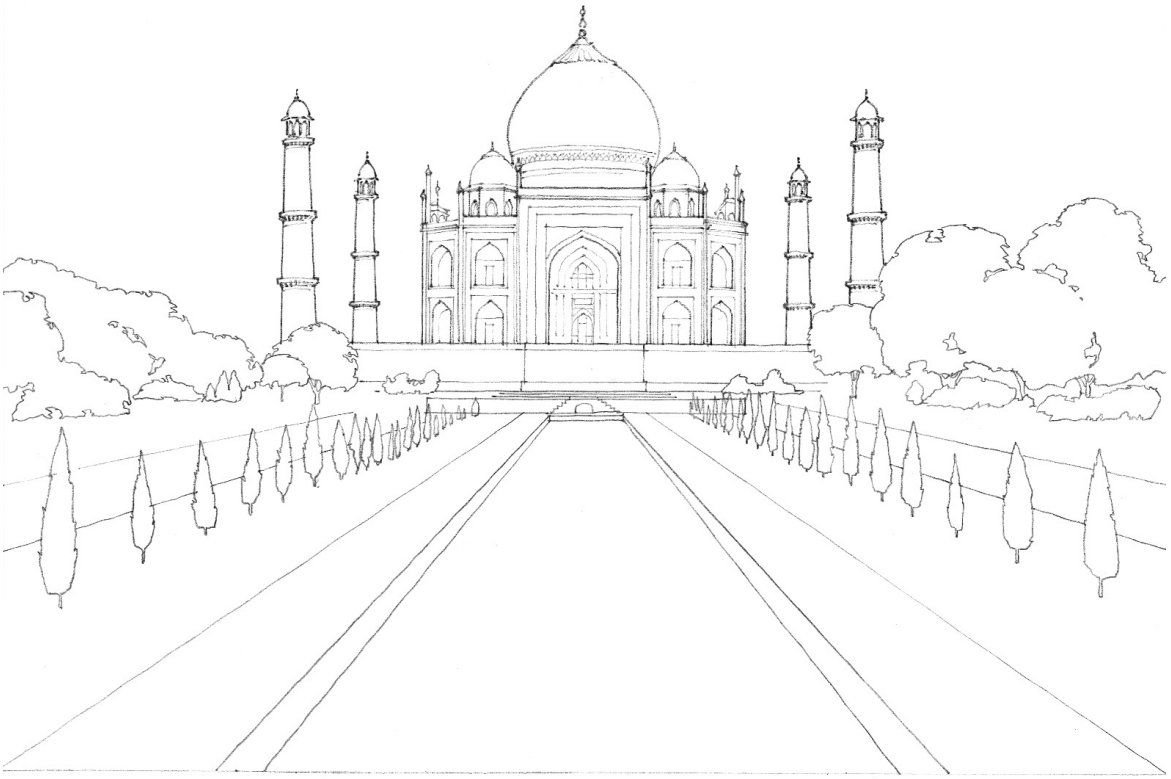
Vertical linear elements can terminate an axis, mark the center of an urban space, or provide a focus for an urban space along its edge.



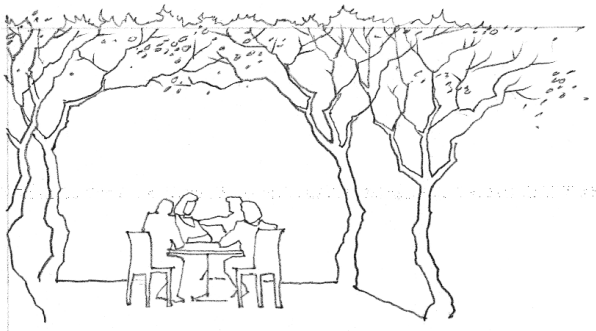
Shokin-Tei Pavilion, **Katsura Imperial Villa**, Kyoto, Japan, 17th century. In the example above, the tokobashira, often a tree trunk in natural form, is a symbolic element that marks one edge of the tokonoma in a Japanese tearoom.



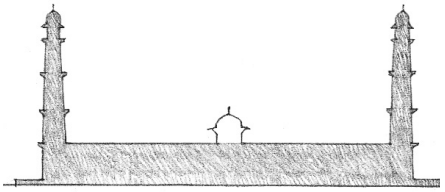
Piazza of St. Peter, Rome, 1655–1667, Giovanni Bernini



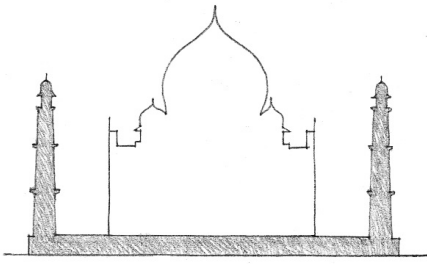
Taj Mahal, Tomb of Muntaz Mahal, wife of Shah Jahan, Agra, India, 1630–1653



A bosket or grove of trees defining a shady place in a garden or park



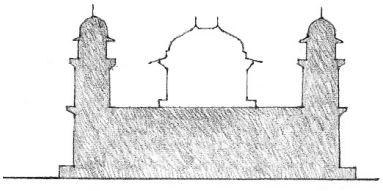
Tomb of Jahangir, near Lahore



Tomb of Muntaz Mahal, Agra

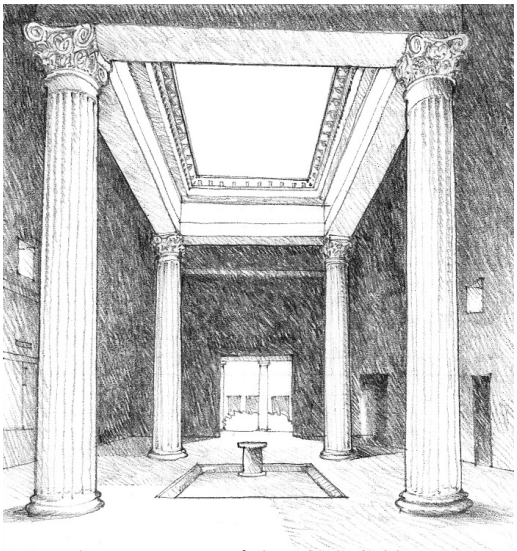
In these examples, various forms of minarets mark the corners of a platform and establish a field of space—a three-dimensional framework—for the Mogul mausoleum structures.

From an analysis of Islamic Indian Architecture by Andras Volwahsen

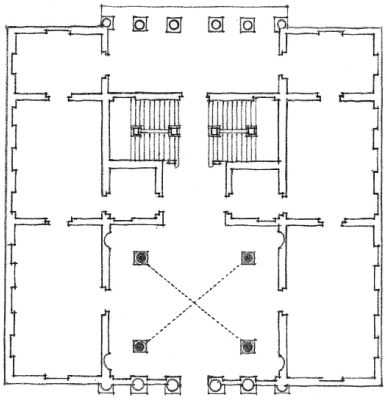


Tomb of I'timad-ud-daula, Agra

VERTICAL LINEAR ELEMENTS



Tetrastyle atrium, **House of the Silver Wedding**, Pompeii, 2nd century B.C.



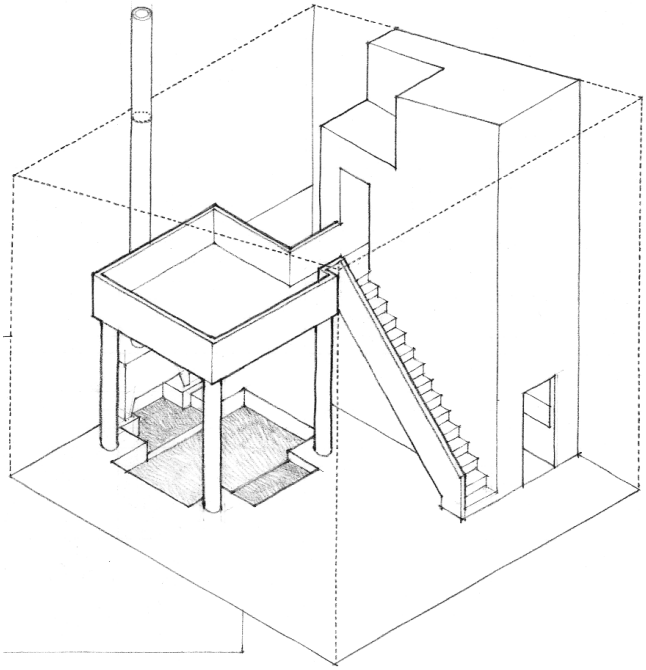
Palazzo Antonini, Udine, Italy, 1556, Andrea Palladio

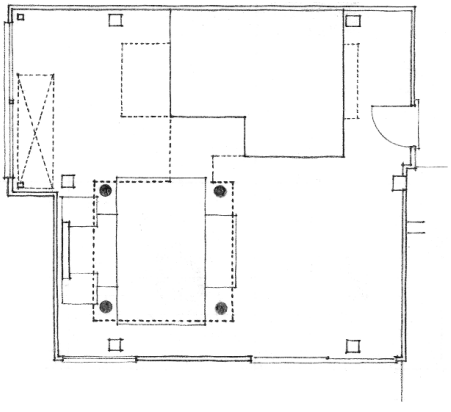
Four columns can establish the corners of a discrete volume of space within a larger room or setting. Supporting a canopy, the columns form an aedicule, a diminutive pavilion that serves as a shrine or the symbolic center of a space.

Traditional Roman houses typically were organized about an atrium open to the sky and surrounded by a roof structure supported at the corners by four columns. Vitruvius termed this a tetrastyle atrium.

During the Renaissance, Andrea Palladio incorporated the tetrastyle theme in the vestibules and halls of a number of villas and palazzi. The four columns not only supported the vaulted ceiling and the floor above but also adjusted the dimensions of the rooms to Palladian proportions.

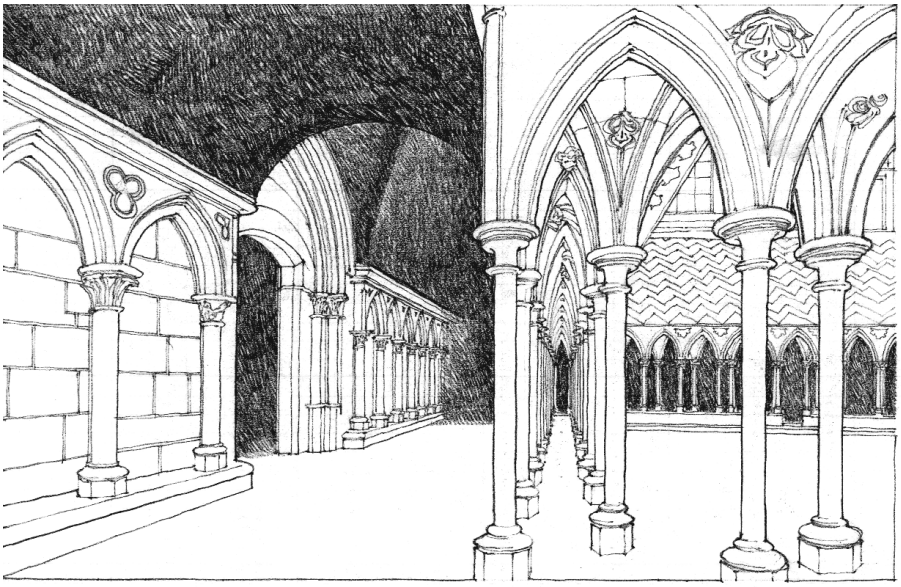
In the Sea Ranch condominium units, four posts along with a sunken floor and an overhead plane define an intimate aedicular space within a larger room.

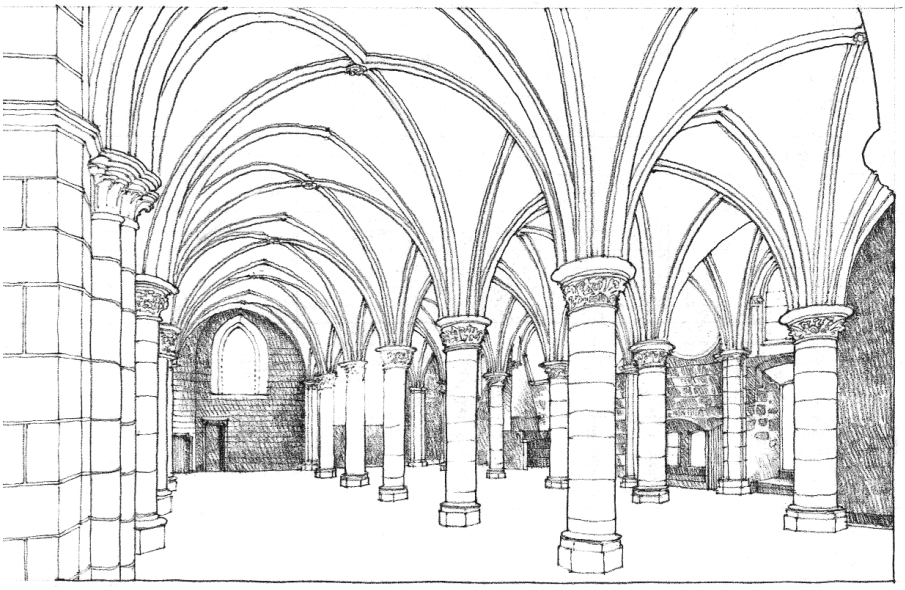


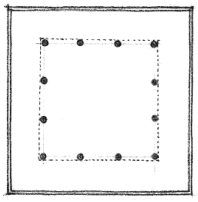


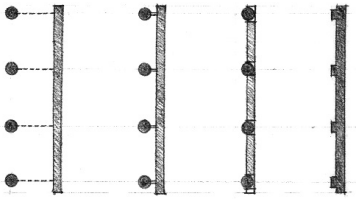
Condominium Unit No. 5, Sea Ranch, California, 1966, MLTW

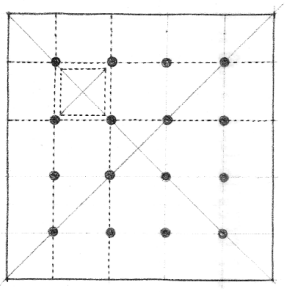
Cloister and Salle des Chevaliers, Mont St. Michel, France, 1203–1228







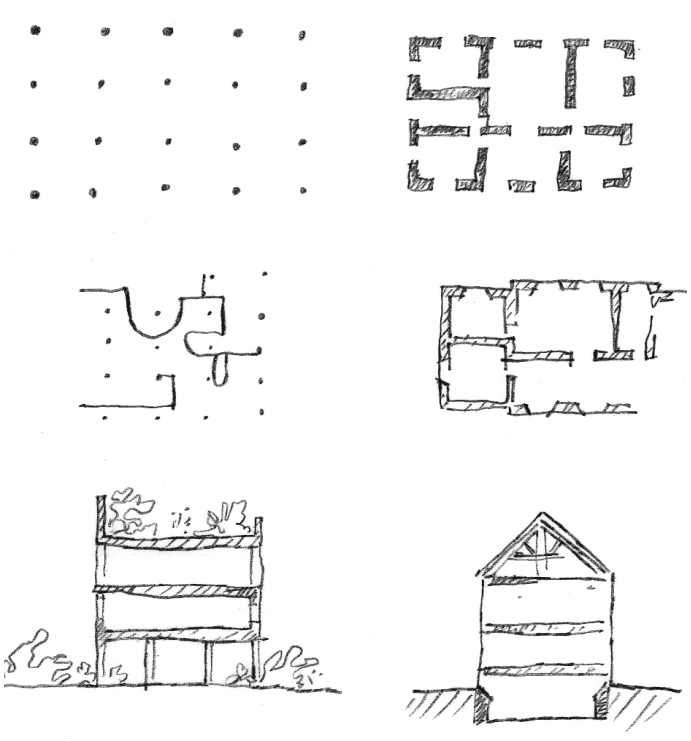




A regularly spaced series of columns or similar vertical elements form a colonnade. This archetypal element in the vocabulary of architectural design effectively defines an edge of a spatial volume while permitting visual and spatial continuity to exist between the space and its surroundings. A row of columns can also engage a wall and become a pilastrade that supports the wall, articulates its surface, and tempers the scale, rhythm, and proportioning of its bays.

A grid of columns within a large room or hall not only serves to support the floor or roof plane above. The orderly rows of columns also punctuate the spatial volume, mark off modular zones within the spatial field, and establish a measurable rhythm and scale that make the spatial dimensions comprehensible.

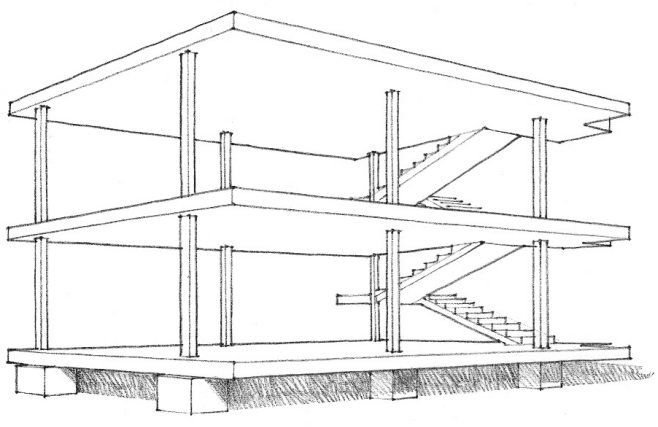
VERTICAL LINEAR ELEMENTS



Sketches for *The Five Points of the New Architecture*, 1926, Le Corbusier

In 1926, Le Corbusier stated what he believed to be the "Five Points of the New Architecture." His observations were to a great extent the result of the development of reinforced concrete construction that began in the late 19th century. This type of construction, in particular the use of concrete columns to support floor and roof slabs, afforded new possibilities for the definition and enclosure of spaces within a building.

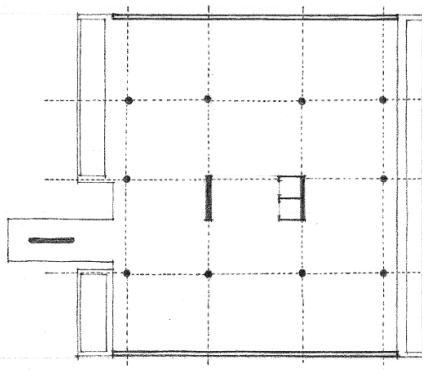
Concrete slabs could cantilever beyond their column supports and enable the "free facade" of the building to be "light membranes" of "screen walls and windows." Within the building, a "free plan" was possible since the enclosure and layout of spaces were not determined or restricted by the pattern of heavy load-bearing walls. Interior spaces could be defined with non-load-bearing partitions, and their layout could respond freely to programmatic requirements.



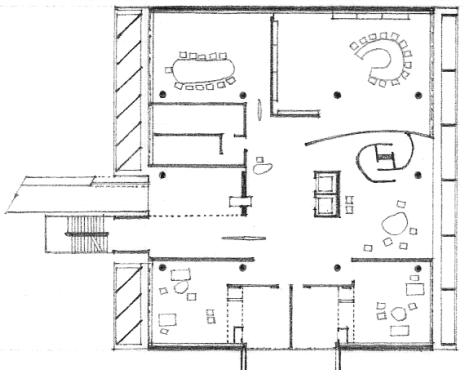
Dom-ino House Project, 1914, Le Corbusier

On the facing page, two contrasting examples of the use of a column grid are illustrated:

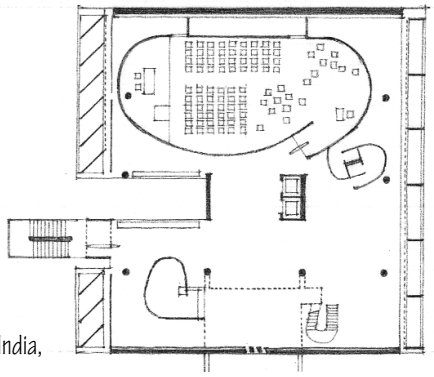
1. A column grid establishes a fixed, neutral field of space in which interior spaces are freely formed and distributed.
2. A grid of columns or posts corresponds closely to the layout of the interior spaces; there is a close fit between structure and space.



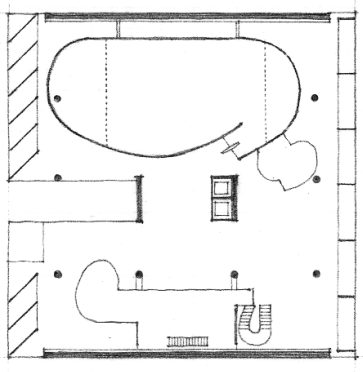
Column-grid pattern



1st floor plan

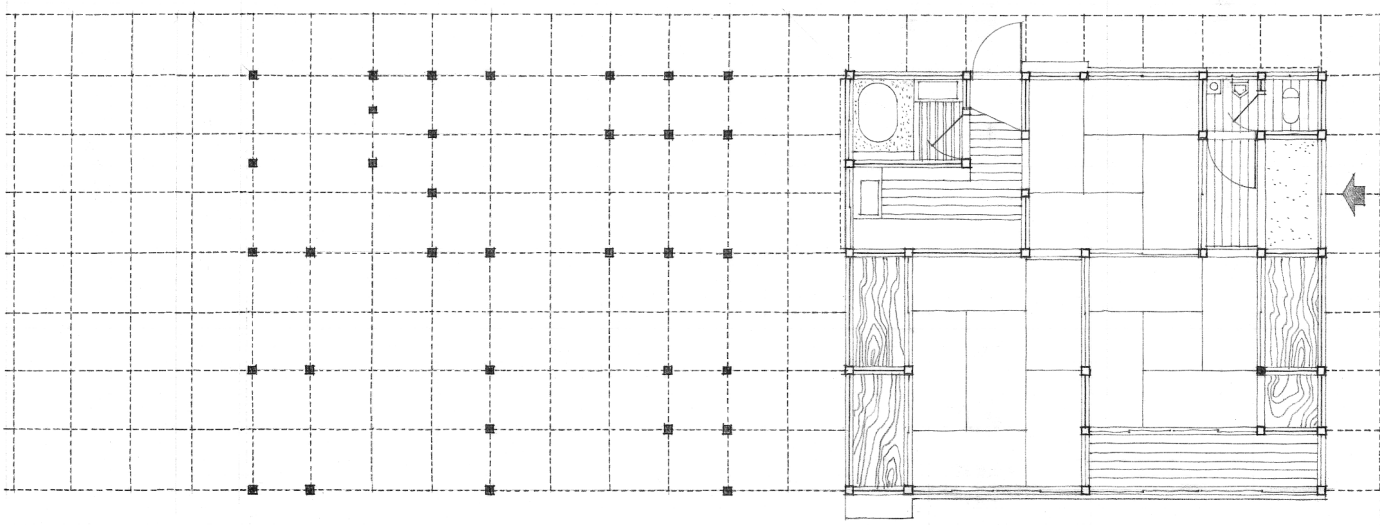


2nd floor plan



3rd floor plan

1. Millowners' Association Building, Ahmedabad, India, 1954, Le Corbusier



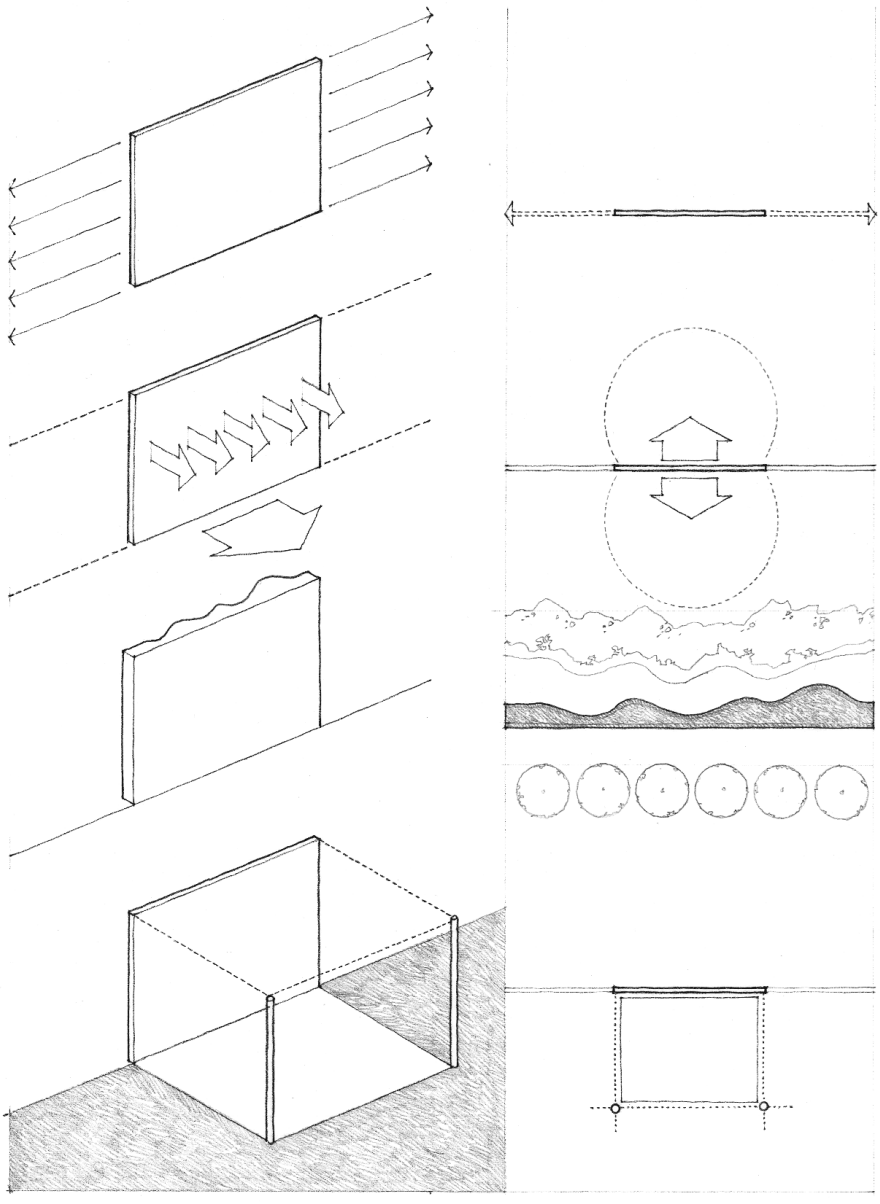
Modular grid

Post pattern

Floor plan

2. Traditional Japanese Residence

SINGLE VERTICAL PLANE



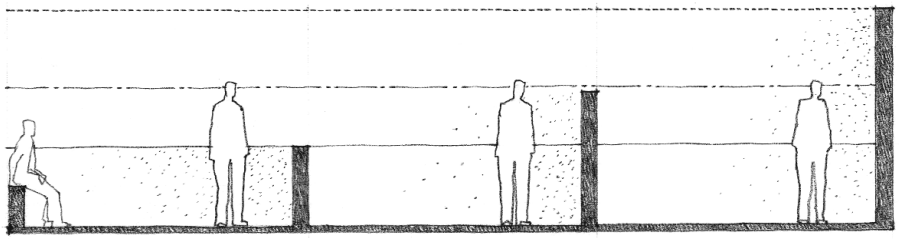
A single vertical plane, standing alone in space, has visual qualities uniquely different from those of a freestanding column. A round column has no preferred direction except for its vertical axis. A square column has two equivalent sets of faces and therefore two identical axes. A rectangular column also has two axes, but they differ in their effect. As the rectangular column becomes more like a wall, it can appear to be merely a fragment of an infinitely larger or longer plane, slicing through and dividing a volume of space.

A vertical plane has frontal qualities. Its two surfaces or faces front on and establish the edges of two separate and distinct spatial fields.

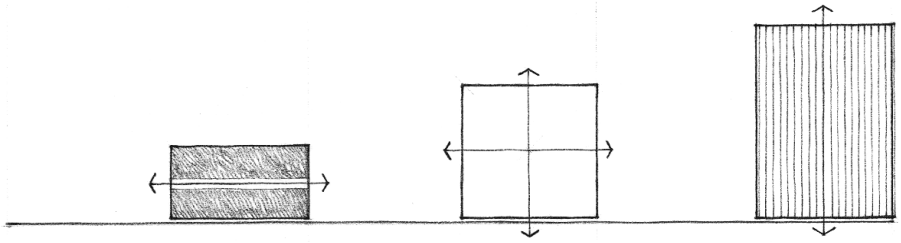
These two faces of a plane can be equivalent and front similar spaces. Or they can be differentiated in form, color, or texture, in order to respond to or articulate different spatial conditions. A vertical plane can therefore have either two fronts or a front and a back.

The field of space on which a single vertical plane fronts is not well-defined. The plane by itself can establish only a single edge of the field. To define a three-dimensional volume of space, the plane must interact with other elements of form.

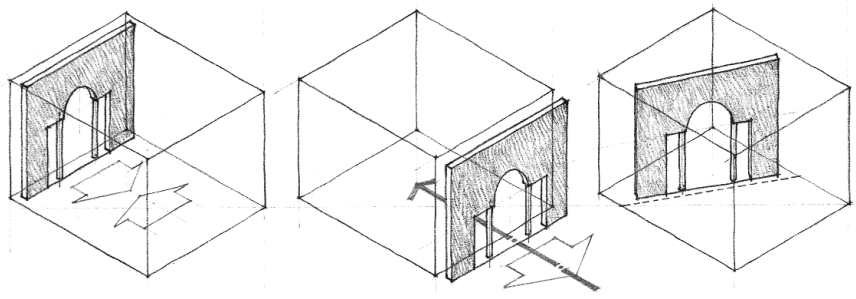
The height of a vertical plane relative to our body height and eye level is the critical factor that affects the ability of the plane to visually describe space. When 2 feet high, a plane defines the edge of a spatial field but provides little or no sense of enclosure. When waist-high, it begins to provide a sense of enclosure while allowing for visual continuity with the adjoining space. When it approaches our eye level in height, it begins to separate one space from another. Above our height, a plane interrupts the visual and spatial continuity between two fields and provides a strong sense of enclosure.



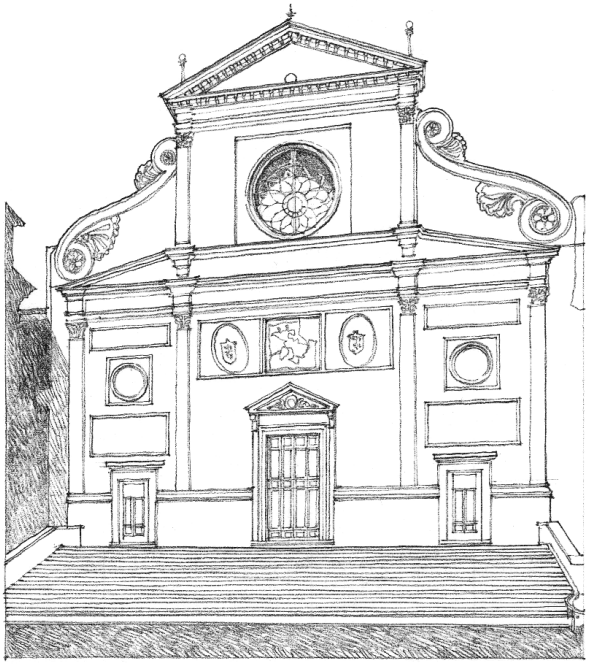
The surface color, texture, and pattern of a plane affect our perception of its visual weight, scale, and proportion.



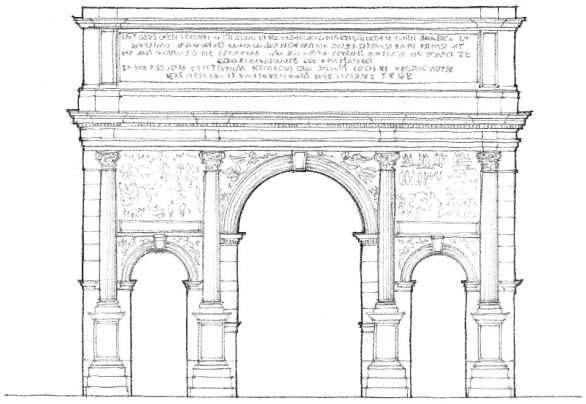
When related to a defined volume of space, a vertical plane can be the primary face of the space and give it a specific orientation. It can front the space and define a plane of entry into it. It can be a freestanding element within a space and divide the volume into two separate but related areas.



SINGLE VERTICAL PLANE

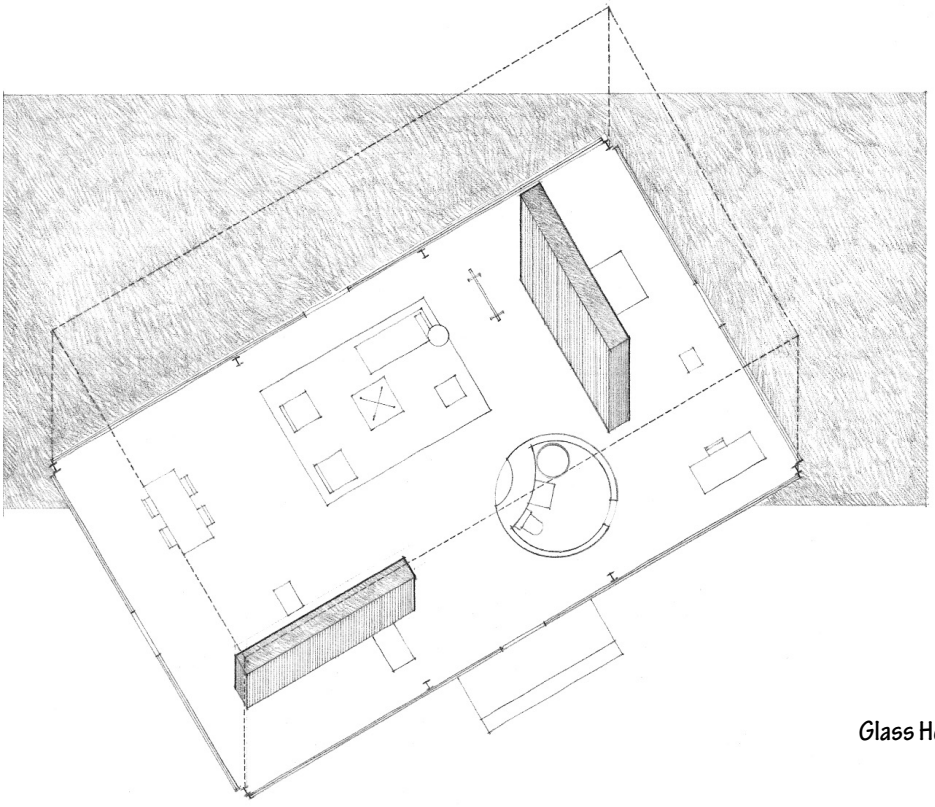


St. Agostino, Rome, 1479–1483, Giacomo da Pietrasanta

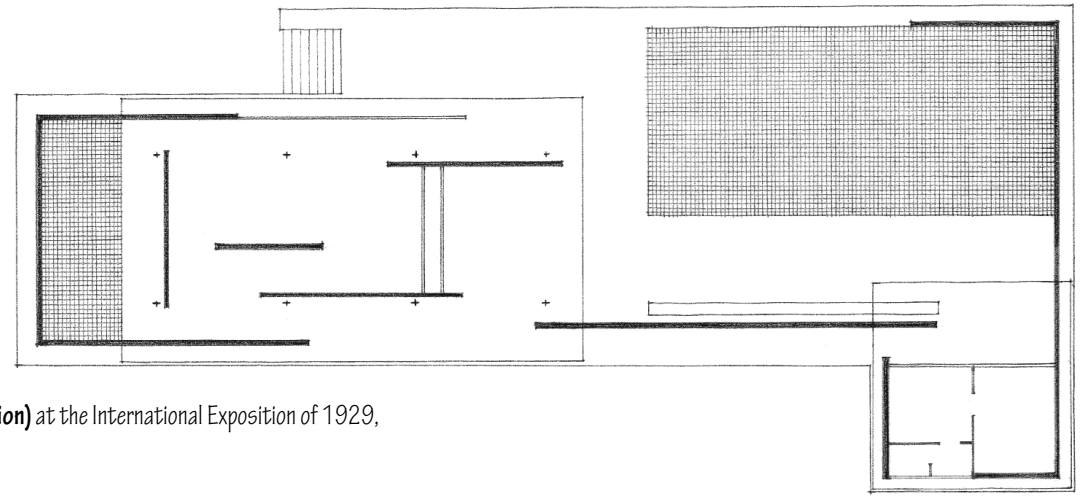


Arch of Septimius Severus, Rome, A.D. 203

A single vertical plane can define the principal facade of a building fronting a public space, establish a gateway through which one passes, as well as articulate spatial zones within a larger volume.

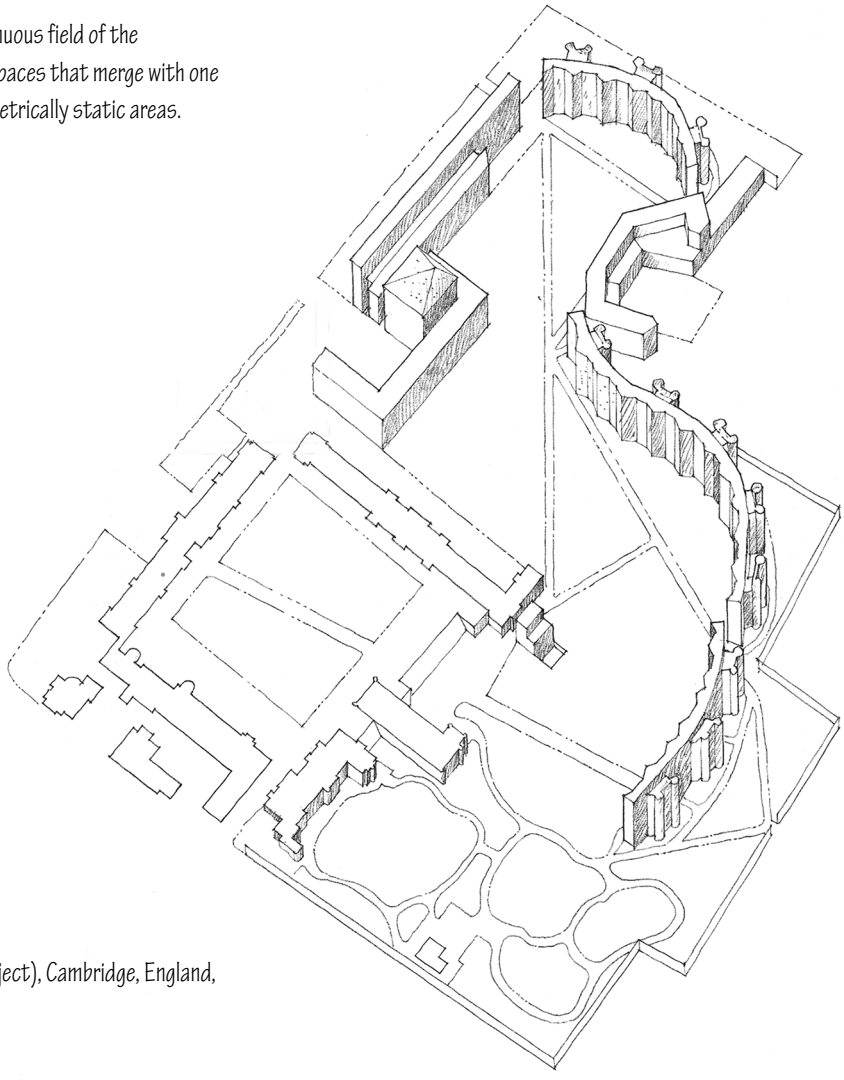


Glass House, New Canaan, Connecticut, 1949, Philip Johnson



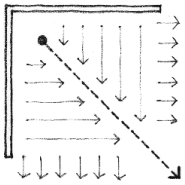
German Pavilion (Barcelona Pavilion) at the International Exposition of 1929, Barcelona, Mies van der Rohe

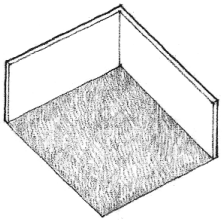
A composition of vertical planes cuts the continuous field of the architectural volume, creating an open plan of spaces that merge with one another. The partitions never form closed, geometrically static areas.

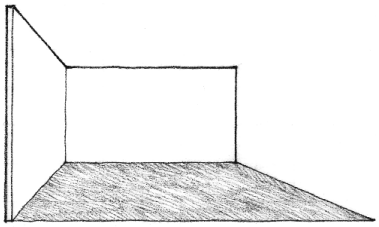


"A Garden-Wall Building"
Student Apartments, Selwyn College (Project), Cambridge, England, 1959, James Stirling and James Gowan

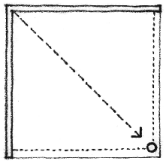
L-SHAPED CONFIGURATION OF PLANES

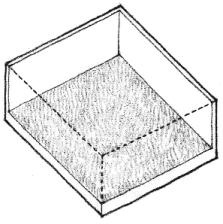


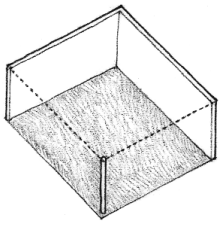




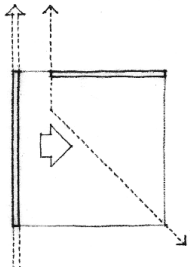
An L-shaped configuration of vertical planes defines a field of space along a diagonal from its corner outward. While this field is strongly defined and enclosed at the corner of the configuration, it dissipates rapidly as it moves away from the corner. The introverted field at the interior corner becomes extroverted along its outer edges.

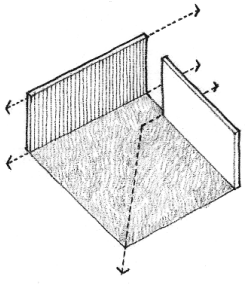




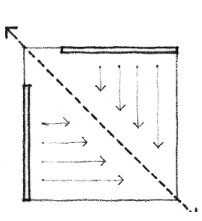


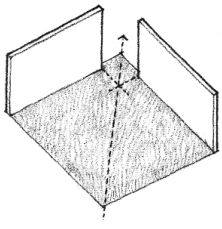
While two edges of the field are clearly defined by the two planes of the configuration, its other edges remain ambiguous unless further articulated by additional vertical elements, manipulations of the base plane, or an overhead plane.





If a void is introduced to one side of the corner of the configuration, the definition of the field will be weakened. The two planes will be isolated from each other and one will appear to slide by and visually dominate the other.

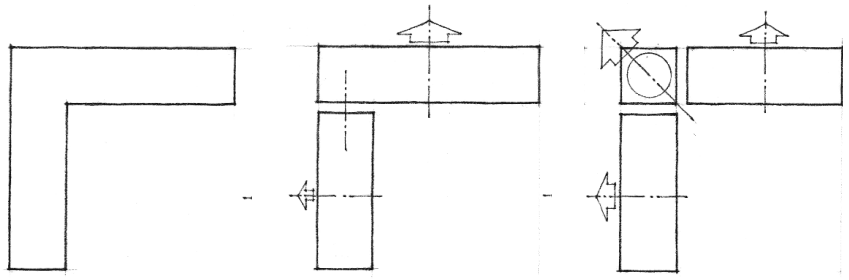




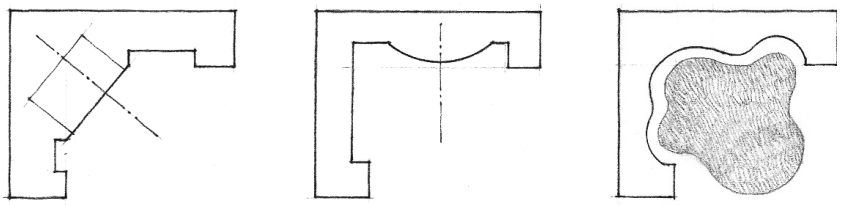
If neither plane extends to the corner, the field will become more dynamic and organize itself along the diagonal of the configuration.

L-SHAPED PLANES

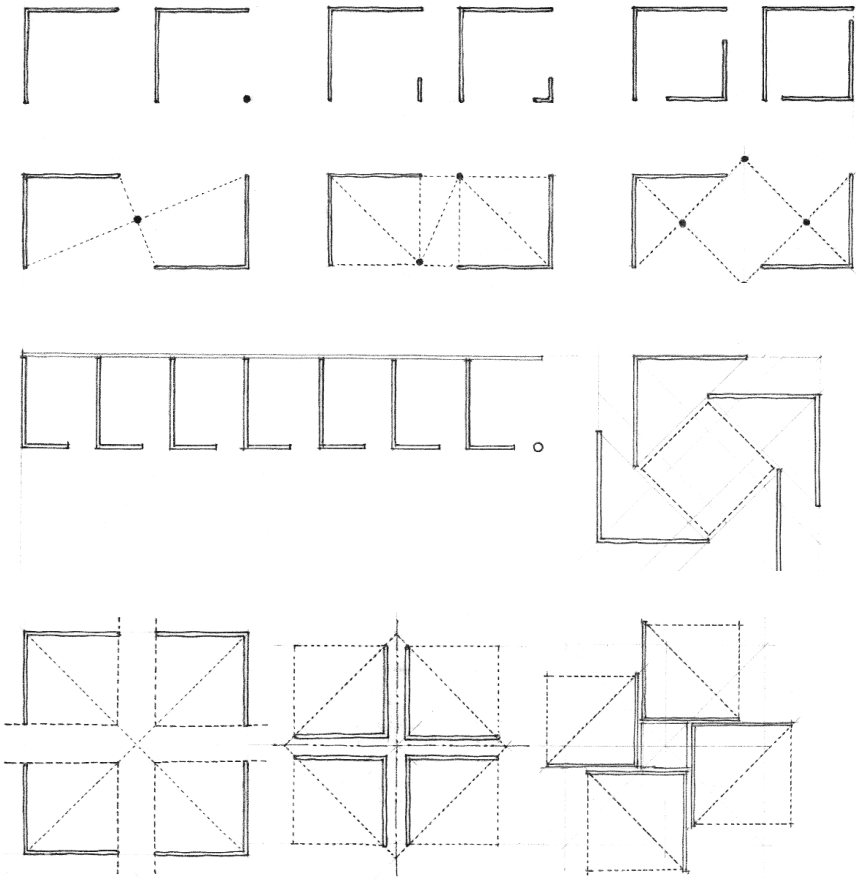
A building form can have an L-shaped configuration and be subject to the following readings. One of the arms of the configuration can be a linear form that incorporates the corner within its boundaries while the other arm is seen as an appendage to it. Or the corner can be articulated as an independent element that joins two linear forms together.



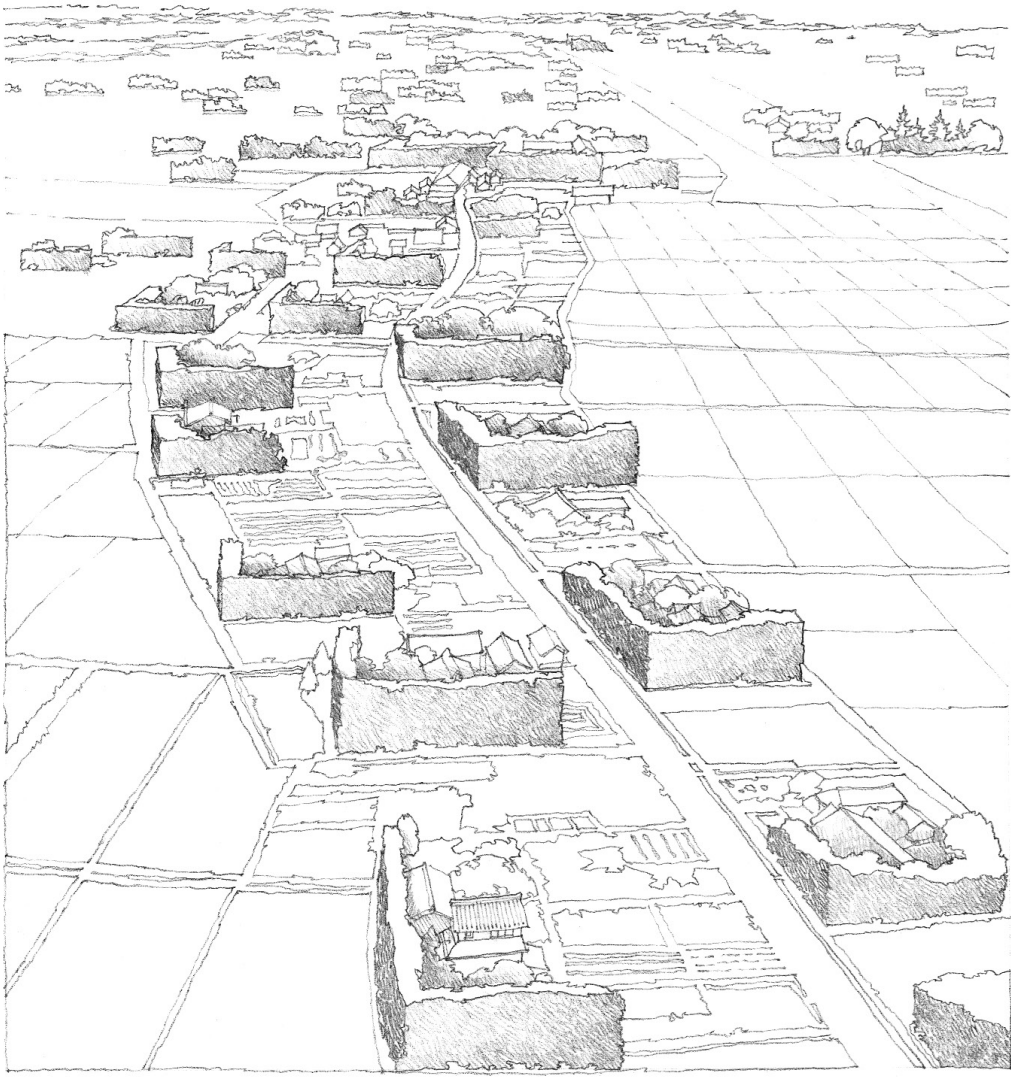
A building can have an L-shaped configuration to establish a corner of its site, enclose a field of outdoor space to which its interior spaces relate, or shelter a portion of outdoor space from undesirable conditions around it.



L-shaped configurations of planes are stable and self-supporting and can stand alone in space. Because they are open-ended, they are flexible space-defining elements. They can be used in combination with one another or with other elements of form to define a rich variety of spaces.

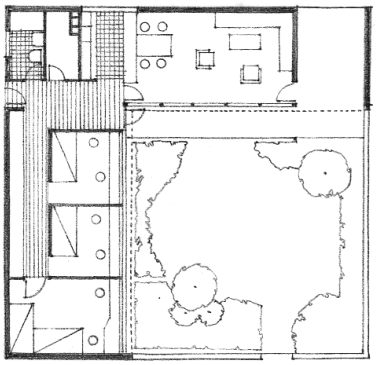


L-SHAPED PLANES

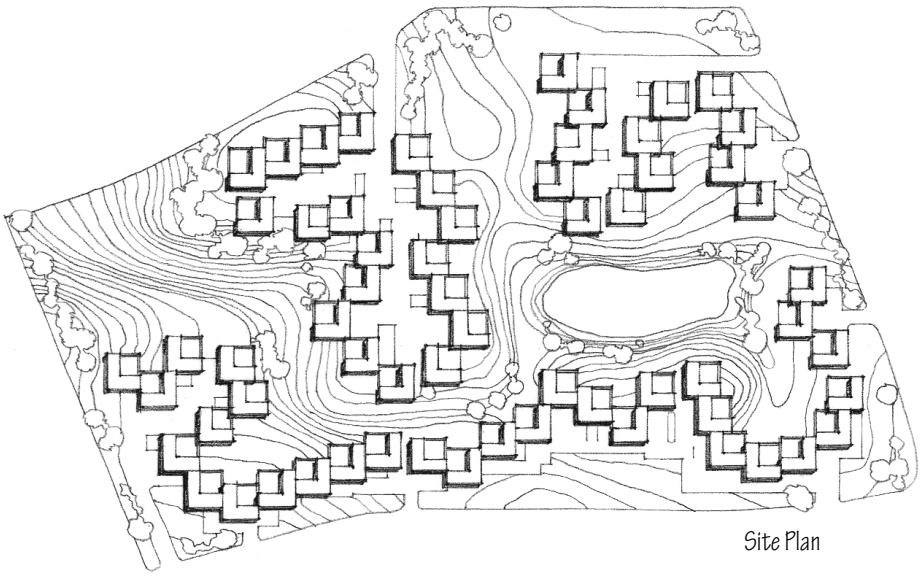


Vegetation forming L-shaped windscreens, Shimane Prefecture, Japan

The sheltering aspect of an L-shaped configuration is expressed well in this example where Japanese farmers coaxed pine trees to grow into tall, thick, L-shaped hedges to shield their houses and land from winter winds and snowstorms.



Basic Housing Unit

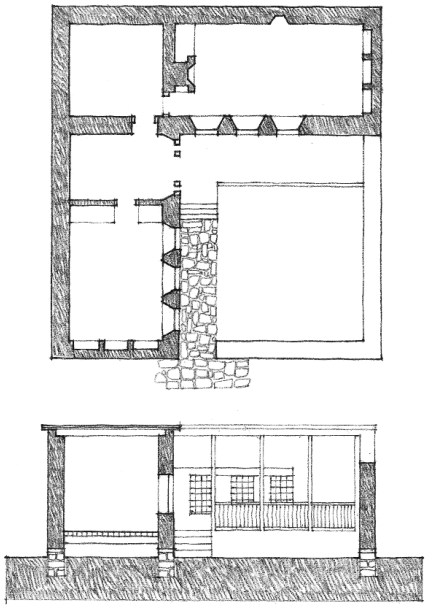


Site Plan

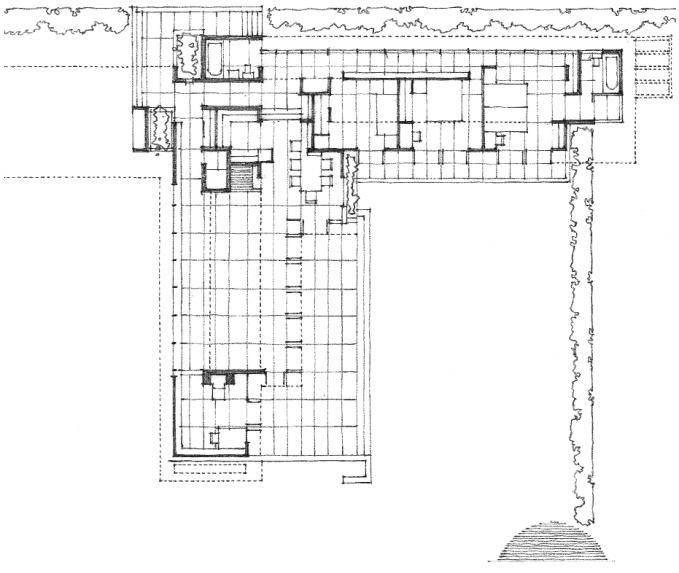
Kingo Housing Estate near Elsinore, Denmark
1958–1963, Jørn Utzon

A common theme found in examples of residential architecture is an L-shaped configuration of rooms enclosing an outdoor living space. Typically, one wing contains the communal living spaces while the other contains private, individual spaces. The service and utility spaces usually occupy a corner position or are strung along the backside of one of the wings.

The advantage of this type of layout is its provision of a private courtyard, sheltered by the building form and to which interior spaces can be directly related. In the Kingo Housing estate, a fairly high density is achieved with this type of unit, each with its own private outdoor space.

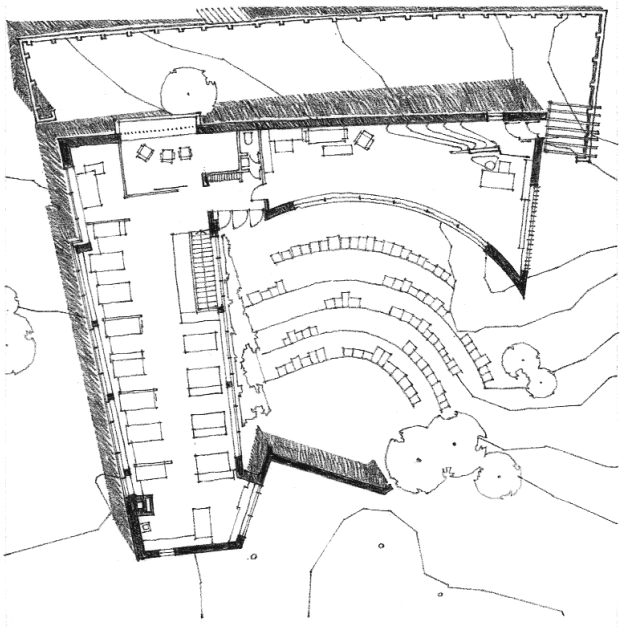


Traditional House in Konya, Turkey



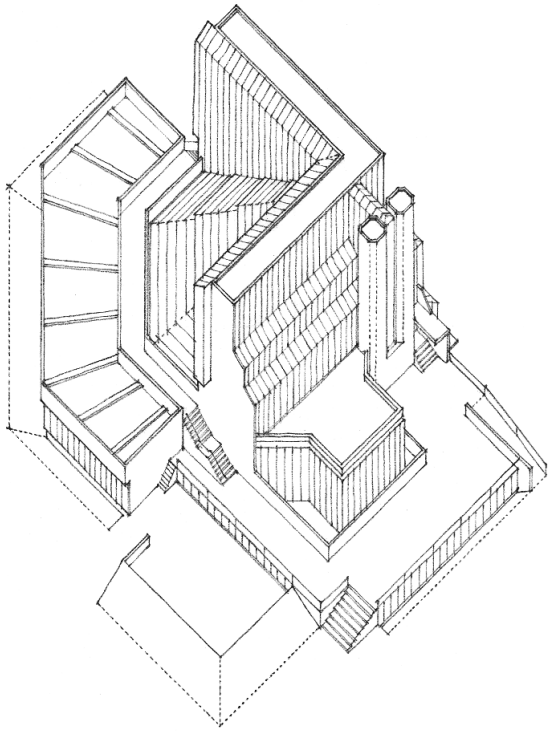
Rosenbaum House, Florence, Alabama, 1939, Frank Lloyd Wright

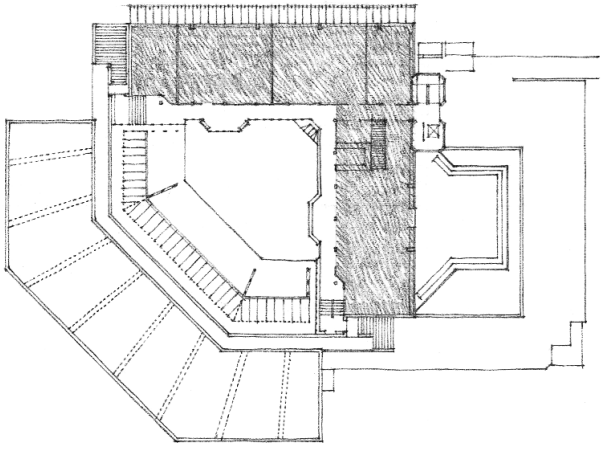
L-SHAPED PLANES



Architect's Studio, Helsinki, 1955–1956, Alvar Aalto

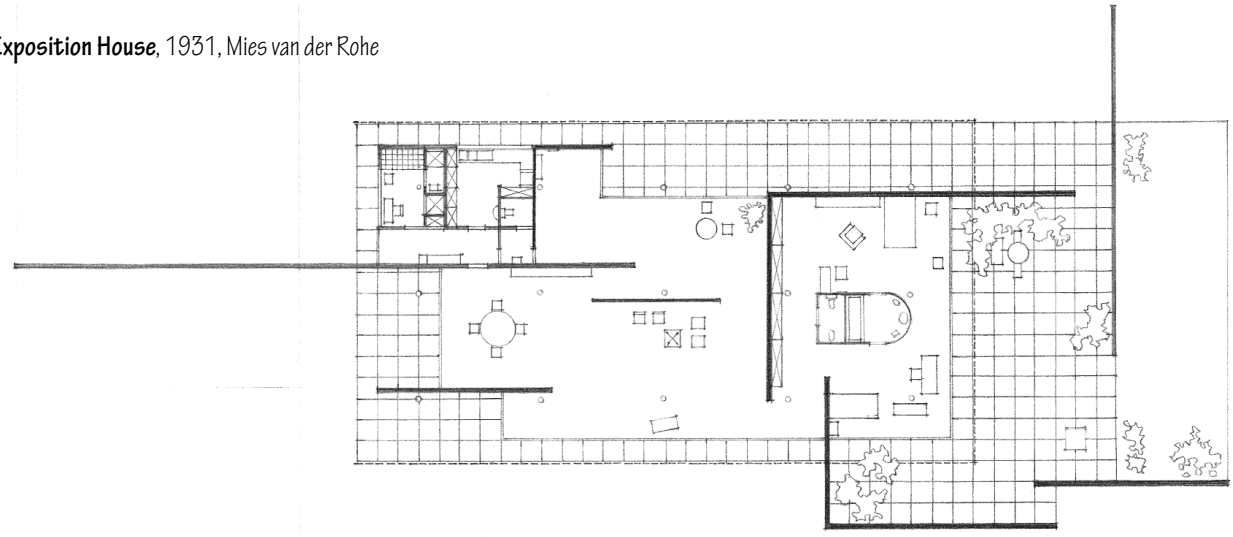
Similar to the residential examples on the preceding page, these buildings use their L-shaped forms as sheltering or enclosing elements. The outdoor space enclosed by the architect's studio in Helsinki is used as an amphitheater for lectures and social occasions. It is not a passive space whose form is determined by the building that encloses it. Rather, it asserts its positive form on the shape of its enclosure. The History Faculty Building at Cambridge uses a seven-story, L-shaped block to functionally and symbolically enclose a large, roof-lit library, which is the most important space in the building.

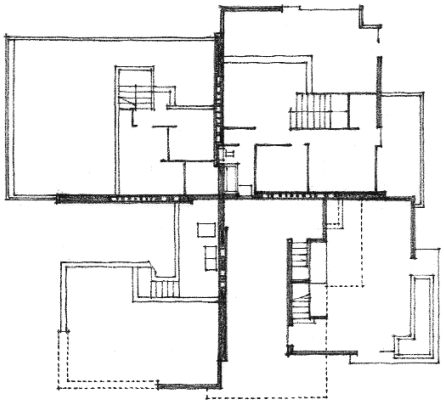




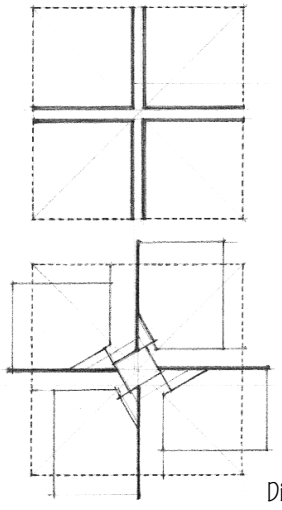
History Faculty Building, **Cambridge University**, England, 1964–1967, James Stirling

Berlin Building Exposition House, 1931, Mies van der Rohe

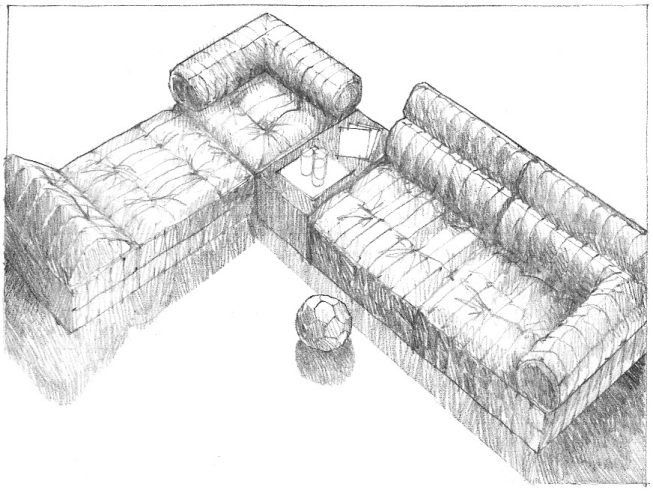




Four-family housing units, **Suntop Homes**,
Ardmore, Pennsylvania, 1939, Frank Lloyd Wright

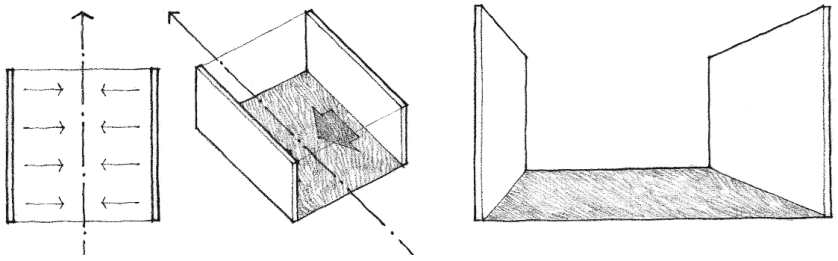


Diagram, **St. Mark's Tower**,
New York City, 1929, Frank Lloyd Wright

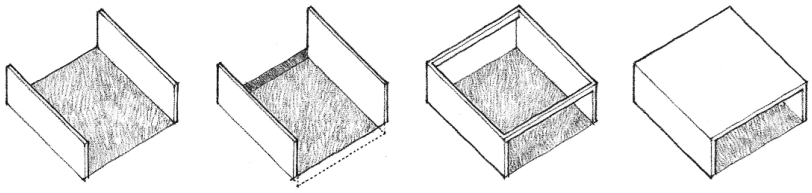


In these examples, L-shaped walls separate the units of a quadruplex housing organization and define zones within a building as well as spaces within a room.

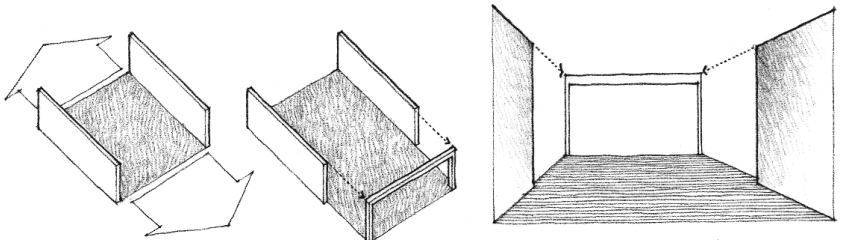
PARALLEL VERTICAL PLANES



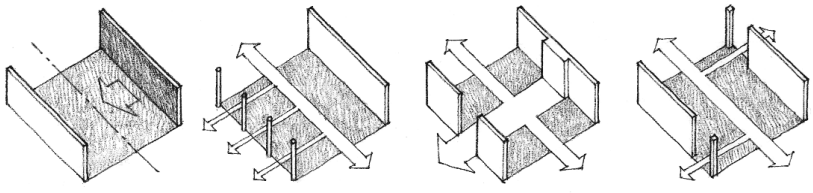
A pair of parallel vertical planes defines a field of space between them. The open ends of the field, established by the vertical edges of the planes, give the space a strong directional quality. Its primary orientation is along the axis about which the planes are symmetrical. Since the parallel planes do not meet to form corners and fully enclose the field, the space is extroverted in nature.



The definition of the spatial field along the open ends of the configuration can be visually reinforced by manipulating the base plane or adding overhead elements to the composition.



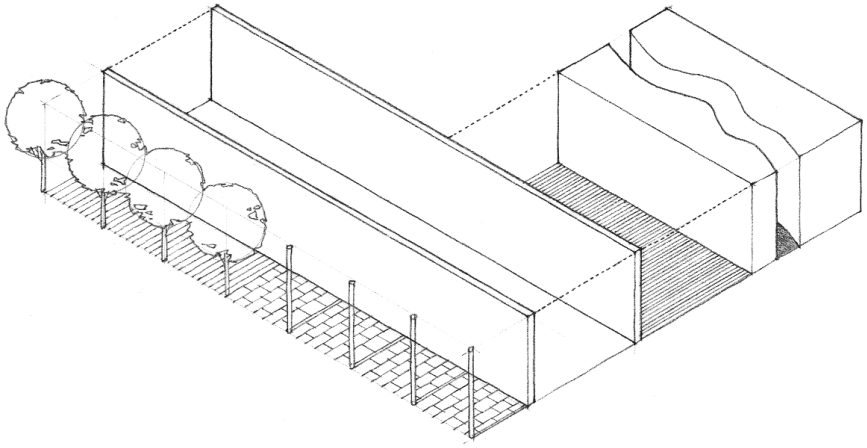
The spatial field can be expanded by extending the base plane beyond the open ends of the configuration. This expanded field can, in turn, be terminated by a vertical plane whose width and height is equal to that of the field.



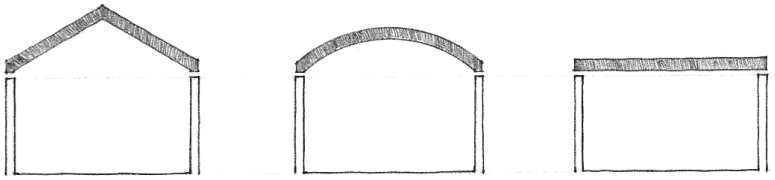
If one of the parallel planes is differentiated from the other by a change in form, color, or texture, a secondary axis, perpendicular to the flow of the space, will be established within the field. Openings in one or both of the planes can also introduce secondary axes to the field and modulate the directional quality of the space.

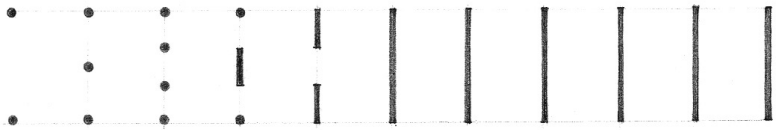
Various elements in architecture can be seen as parallel planes that define a field of space:

- Pair of parallel interior walls within a building
- Street space formed by the facades of two facing buildings
- Colonnaded arbor or pergola
- Promenade or allée bordered by rows of trees or hedges
- Natural topographical form in the landscape

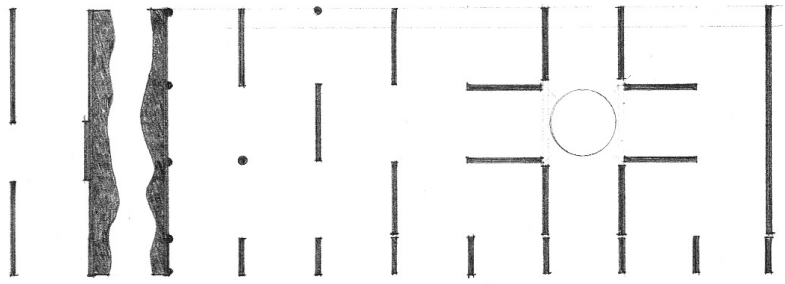


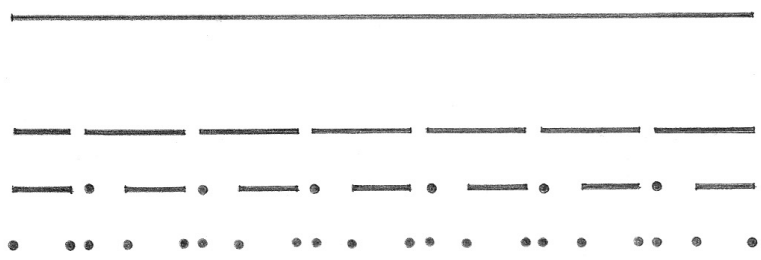
The image of parallel vertical planes is often associated with the bearing-wall structural system, wherein a floor or roof structure spans the spaces between two or more parallel load-bearing walls.



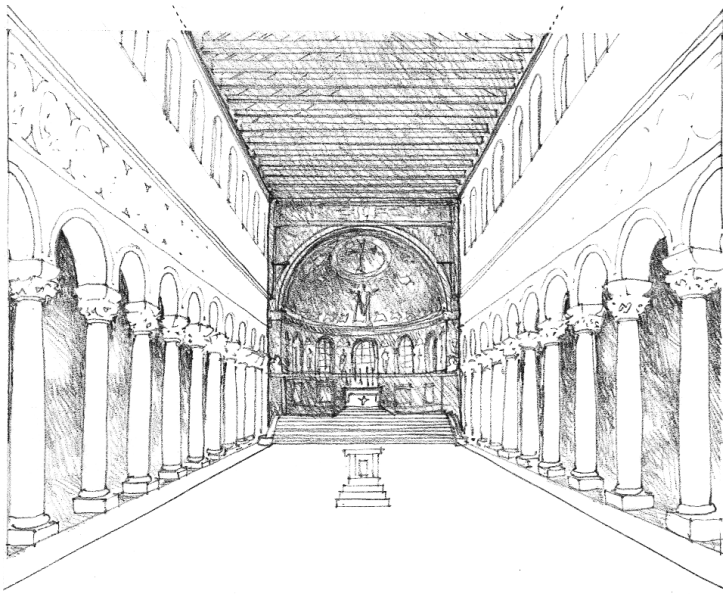


Sets of parallel vertical planes can be transformed into a wide variety of configurations. Their spatial fields can be related to one another either through the open ends of their configurations or through openings in the planes themselves.



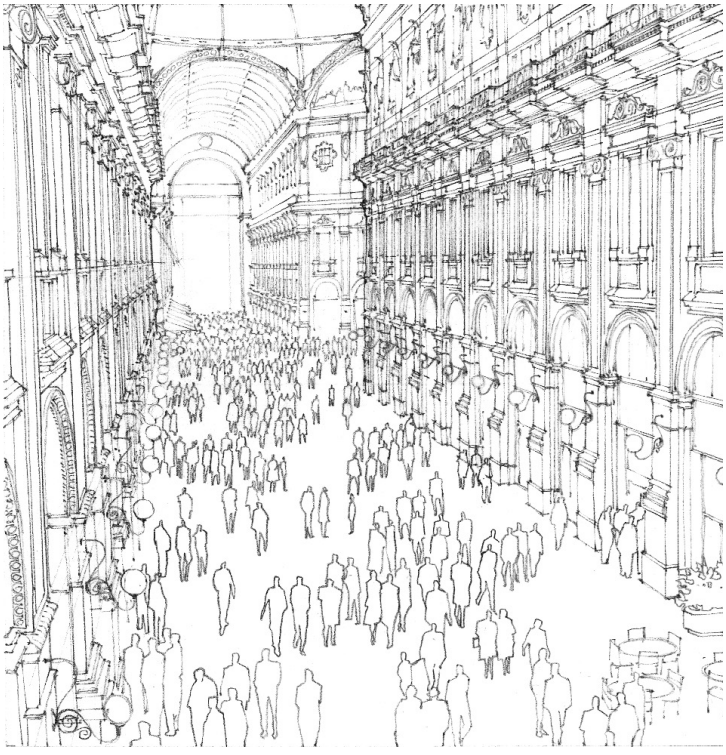


PARALLEL PLANES



Nave of the basilican church, **St. Apollinare in Classe**, Ravenna, Italy, 534–539

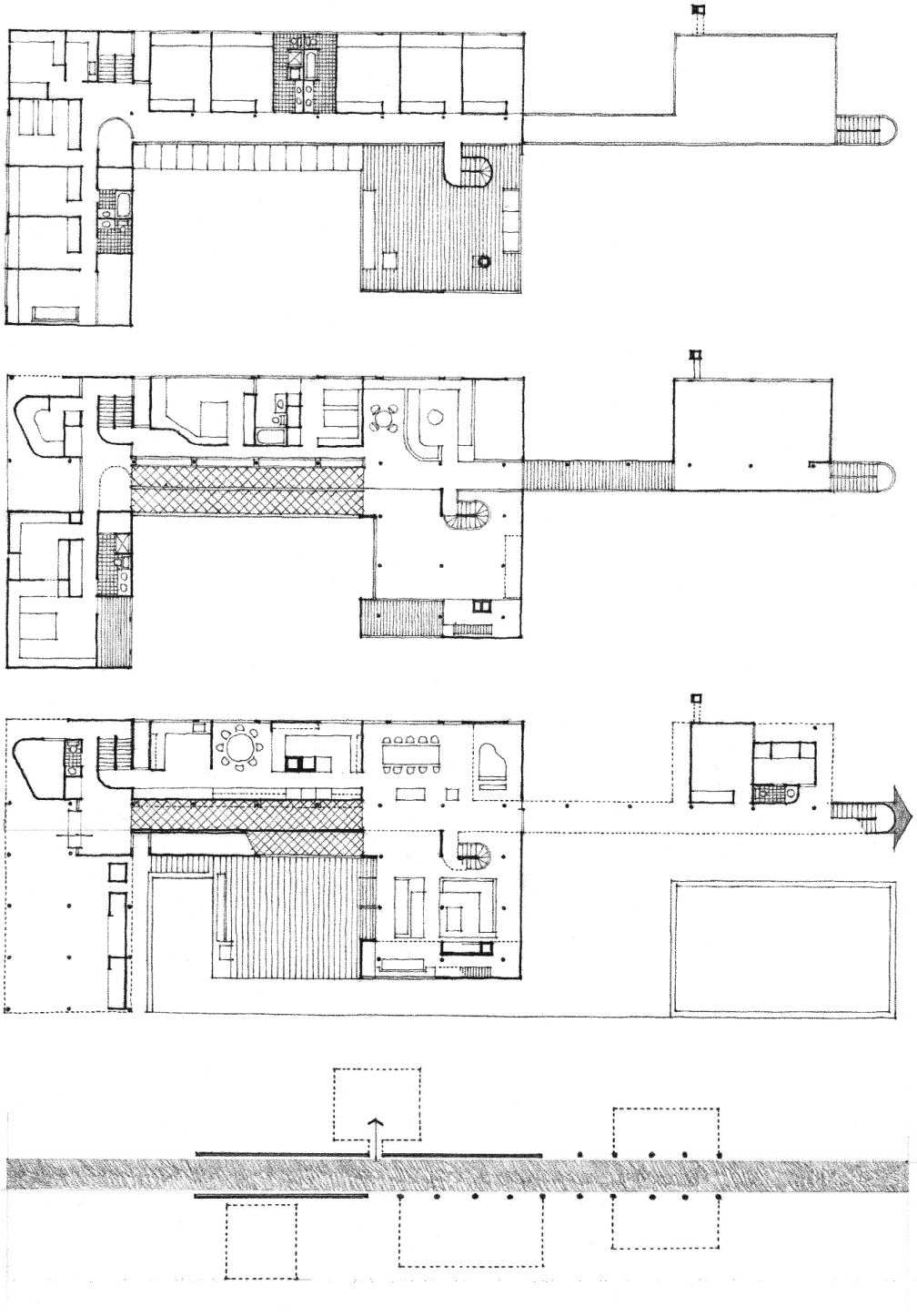
Champ de Mars, Paris



The directional quality and flow of the space defined by parallel planes are naturally manifested in spaces used for circulation and movement, such as the streets and boulevards of towns and cities. These linear spaces can be defined by the facades of the buildings fronting them, as well as by the more permeable planes established by colonnades, arcades, or rows of trees.

Galleria Vittorio Emanuelle II, Milan, Italy, 1865–1877, Giuseppe Mengoni

House in Old Westbury, New York, 1969–1971, Richard Meier



Upper level

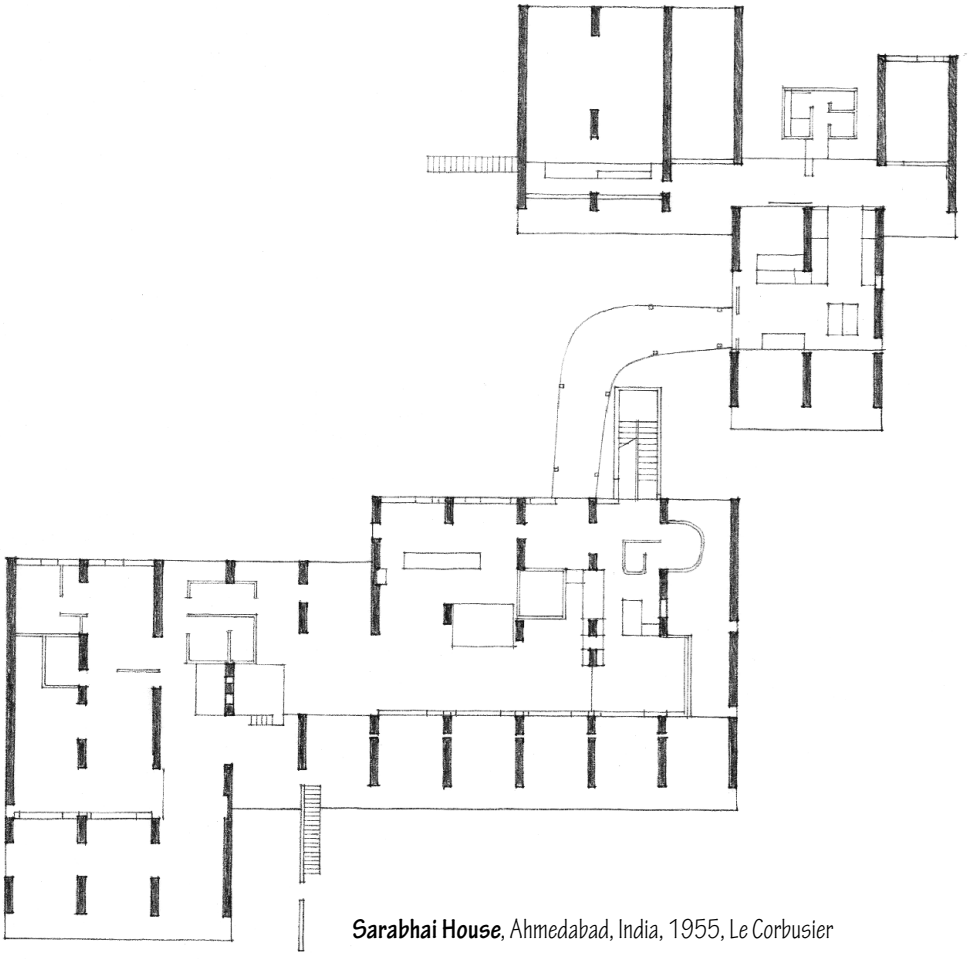
Middle level

Ground level

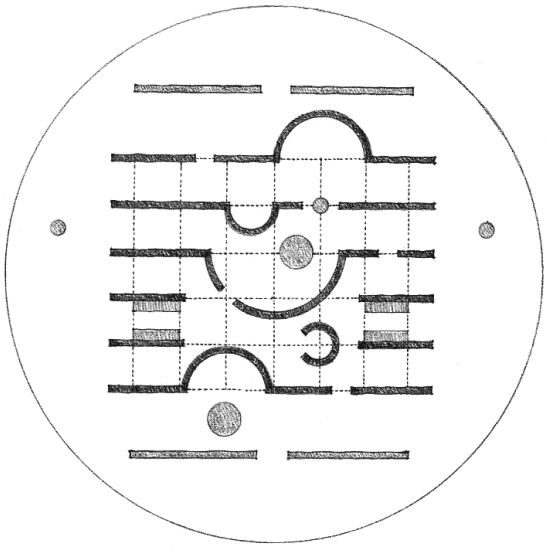
The flow of the space defined by parallel planes corresponds naturally to the paths of movement within a building, along its corridors, halls, and galleries.

The parallel planes that define a circulation space can be solid and opaque to provide privacy for the spaces along the circulation path. The planes can also be established by a row of columns so that the circulation path, open on one or both of its sides, becomes part of the spaces through which it passes.

PARALLEL PLANES



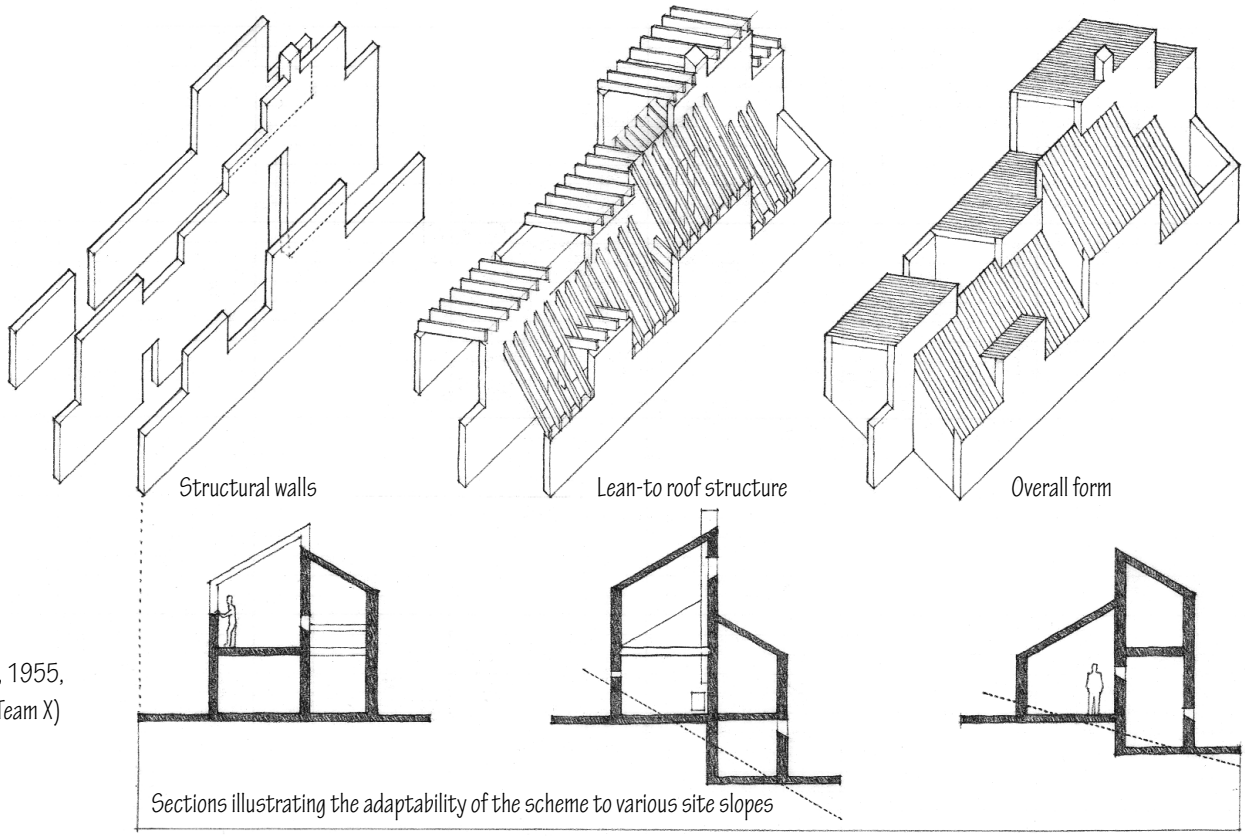
Sarabhai House, Ahmedabad, India, 1955, Le Corbusier



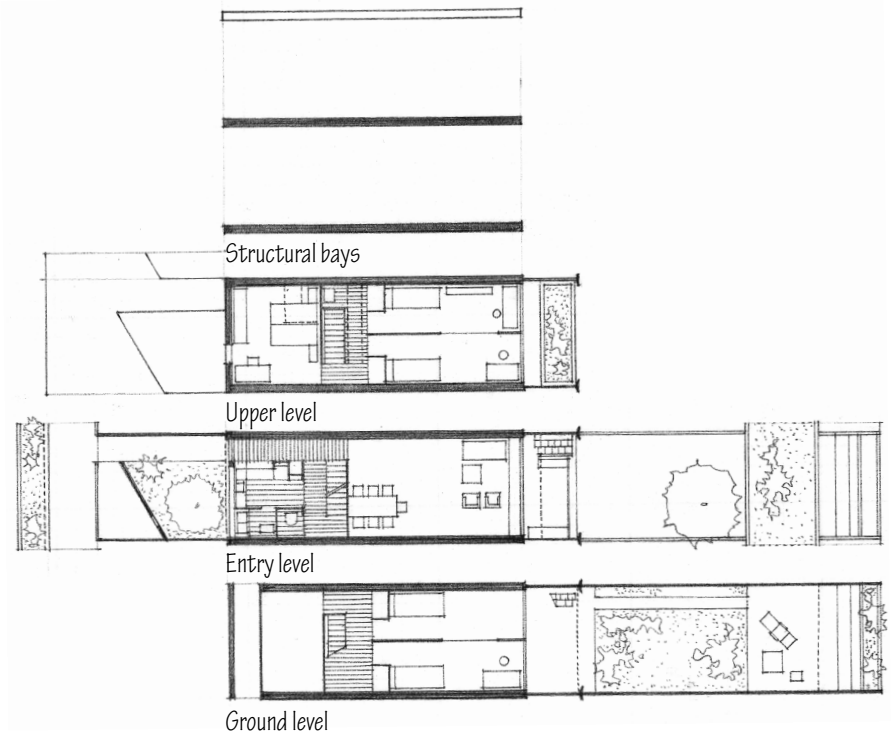
Arnheim Pavilion, The Netherlands, 1966, Aldo van Eyck

The parallel vertical planes of a bearing-wall structural system can be the generating force behind the form and organization of a building. Their repetitive pattern can be modified by varying their length or by introducing voids within the planes to accommodate the dimensional requirements of larger spaces. These voids can also define circulation paths and establish visual relationships perpendicular to the wall planes.

The slots of space defined by parallel wall planes can also be modulated by altering the spacing and configuration of the planes.



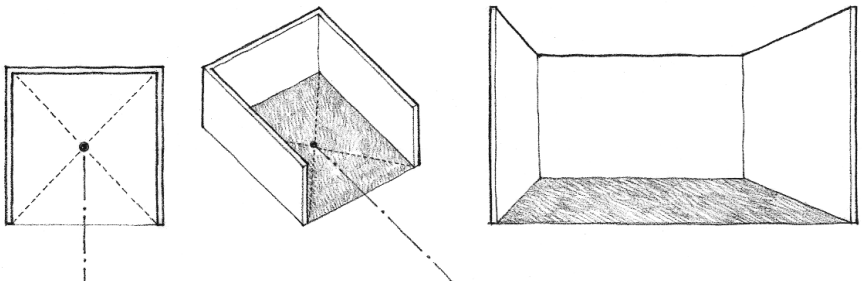
Village Project, 1955,
James Stirling (Team X)



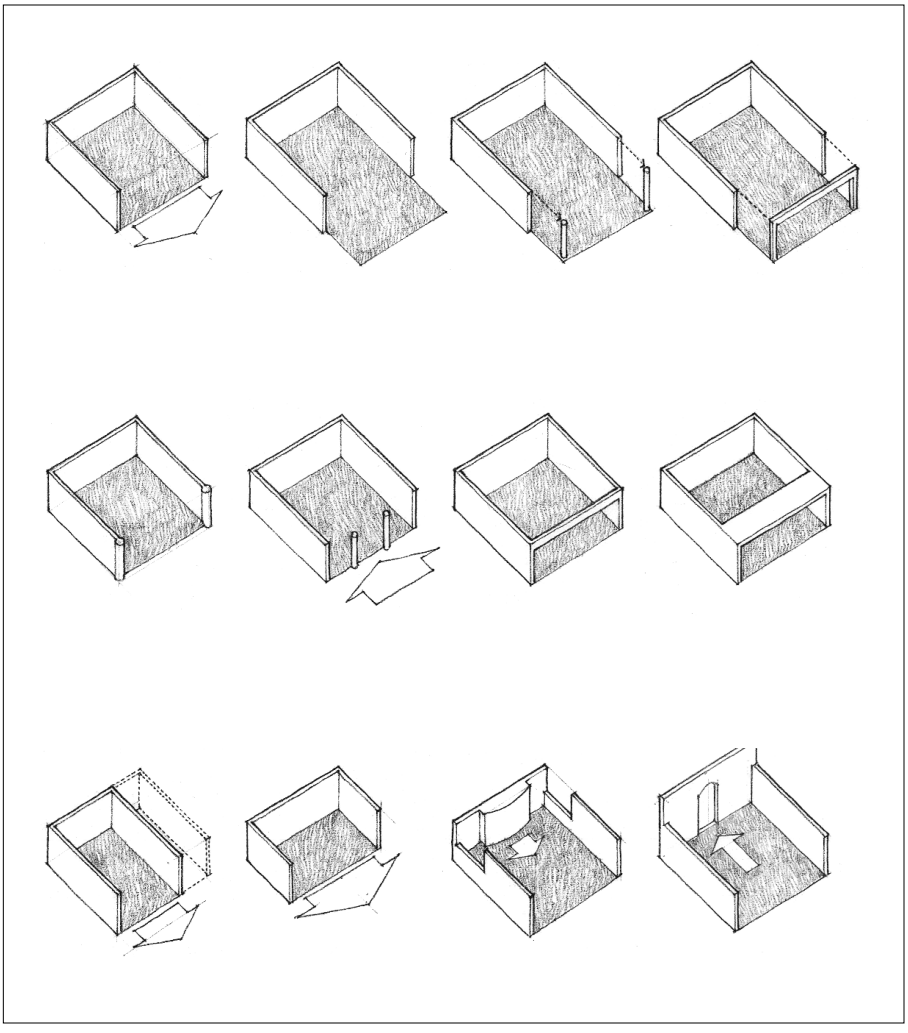
Siedlung Halen, near Bern, Switzerland, 1961, Atelier 5

Parallel bearing walls are often used in multifamily housing developments. They not only provide structural support for the floors and roofs of each housing unit but also serve to isolate the units from one another, curb the passage of sound, and check the spread of fire. The pattern of parallel bearing walls is particularly appropriate for rowhousing and townhouse schemes where each unit is provided with two orientations.

U-SHAPED PLANES



A U-shaped configuration of vertical planes defines a field of space that has an inward focus as well as an outward orientation. At the closed end of the configuration, the field is well defined. Toward the open end of the configuration, the field becomes extroverted in nature.

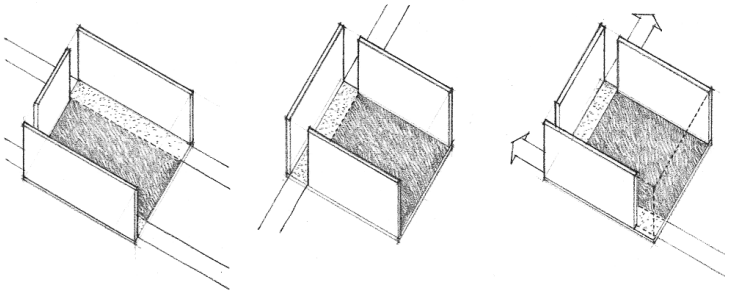


The open end is the primary aspect of the configuration by virtue of its uniqueness relative to the other three planes. It allows the field to have visual and spatial continuity with the adjoining space. The extension of the spatial field into the adjoining space can be visually reinforced by continuing the base plane beyond the open end of the configuration.

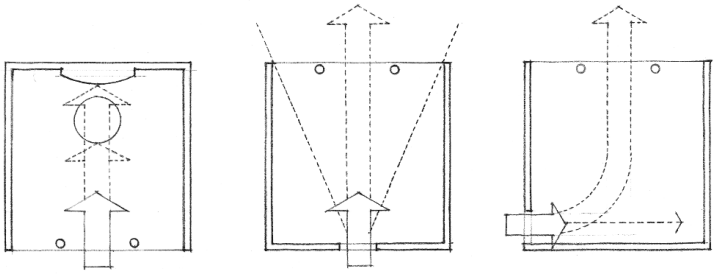
If the plane of the opening is further defined with columns or overhead elements, the definition of the original field will be reinforced and continuity with the adjoining space will be interrupted.

If the configuration of planes is rectangular and oblong in form, the open end can be along its narrow or wide side. In either case, the open end will remain the primary face of the spatial field, and the plane opposite the open end will be the principal element among the three planes of the configuration.

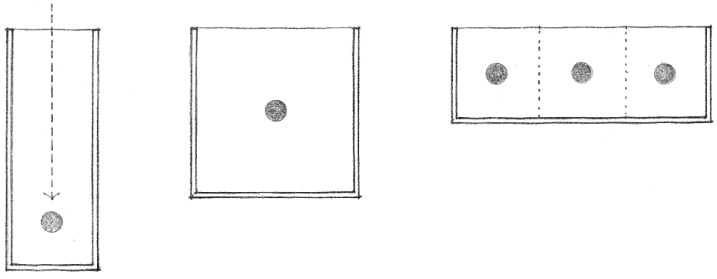
If openings are introduced at the corners of the configuration, secondary zones will be created within a multidirectional and dynamic field.



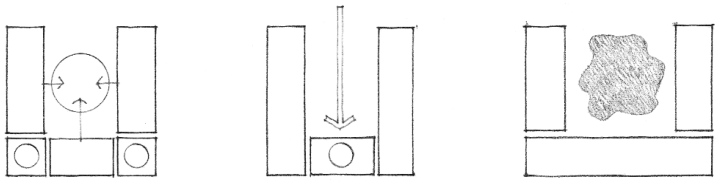
If the field is entered through the open end of the configuration, the rear plane, or a form placed in front of it, will terminate our view of the space. If the field is entered through an opening in one of the planes, the view of what lies beyond the open end will draw our attention and terminate the sequence.



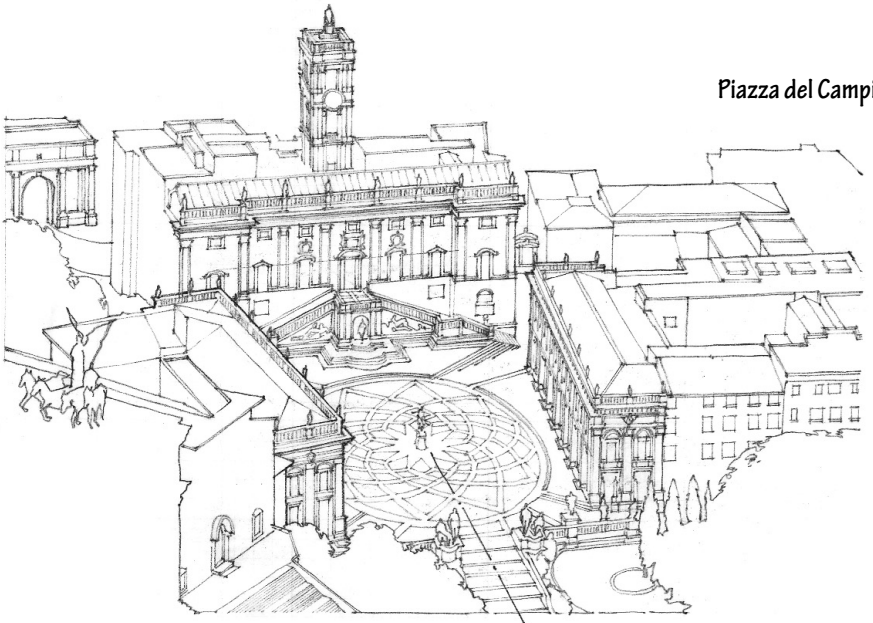
If the end of a long, narrow field is open, the space will encourage movement and induce a progression or sequence of events. If the field is square, or nearly square, the space will be static and have the character of a place to be in, rather than a space to move through. If the side of a long, narrow field is open, the space will be susceptible to a subdivision into a number of zones.



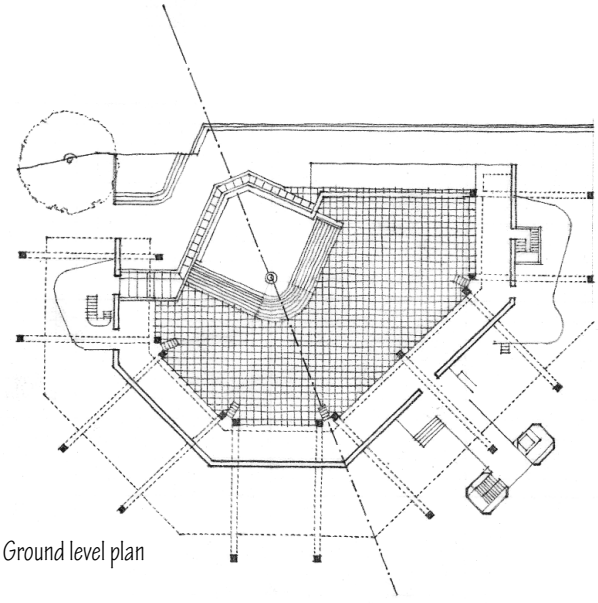
U-shaped configurations of building forms and organizations have the inherent ability to capture and define outdoor space. Their composition can be seen to consist essentially of linear forms. The corners of the configuration can be articulated as independent elements or can be incorporated into the body of the linear forms.



U-SHAPED PLANES

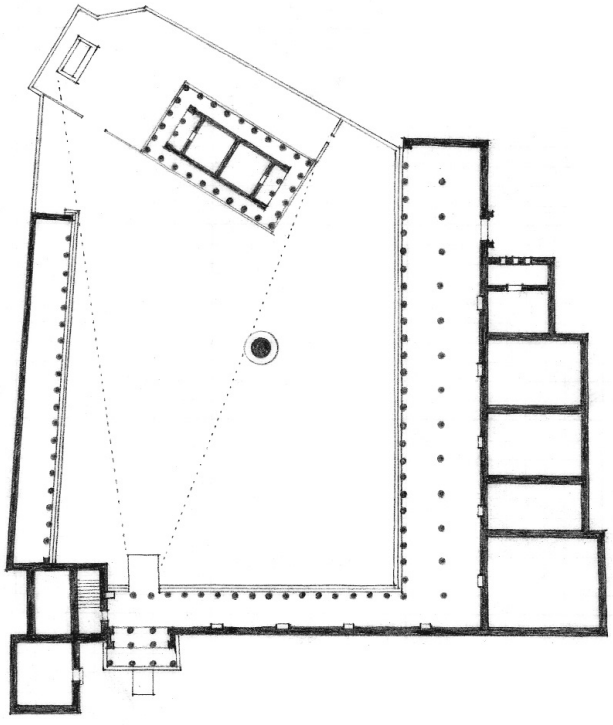


Piazza del Campidoglio, Rome, c. 1544, Michelangelo



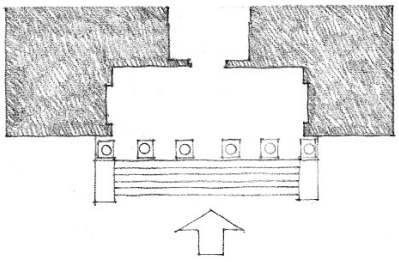
Ground level plan

Florey Building, **Queen's College**, Oxford, 1966–1971, James Stirling

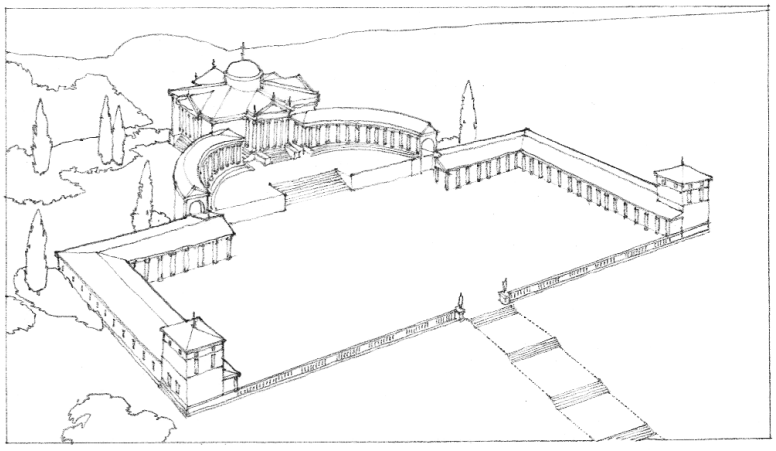


Sacred Precinct of Athena, Pergamon, Asia Minor, 4th century B.C.

U-shaped configurations of building forms can serve to define an urban space and terminate an axial condition. They can also focus on an important or significant element within their fields. When an element is placed along the open end of its field, it gives the field a point of focus as well as a greater sense of closure.

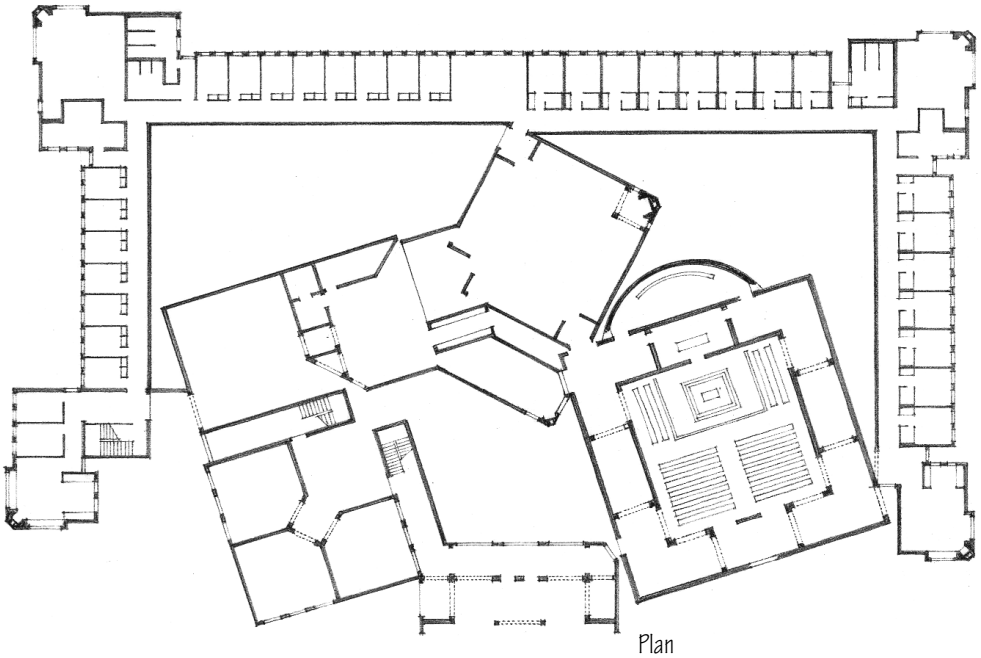


A U-shaped organization can define a forecourt for the approach to a building as well as form an entrance recessed within the building volume.

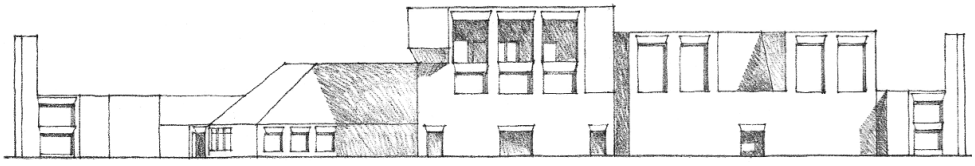


Villa Trissino at Meledo, From *The Four Books on Architecture*, Andrea Palladio

A U-shaped building form can also serve as a container and can organize within its field a cluster of forms and spaces.



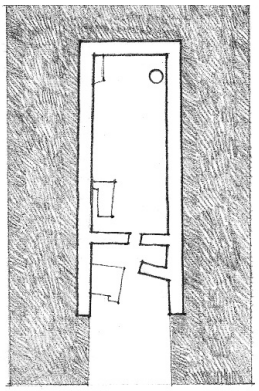
Plan



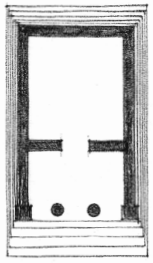
Front elevation

Convent for the Dominican Sisters (project), Media, Pennsylvania, 1965–1968, Louis Kahn. The cells form an enclave for a village of community rooms.

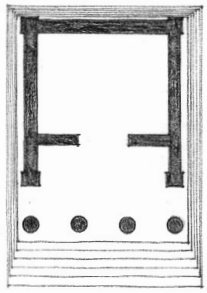
U-SHAPED PLANES



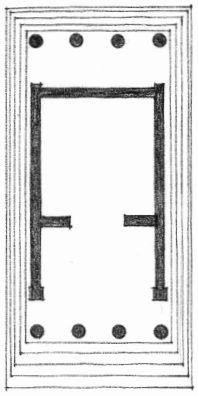
Early Megaron Space
Principal room or hall of an early Anatolian or Aegean house



Temple of Nemesis, Rhamnus



Temple "B," Selinus

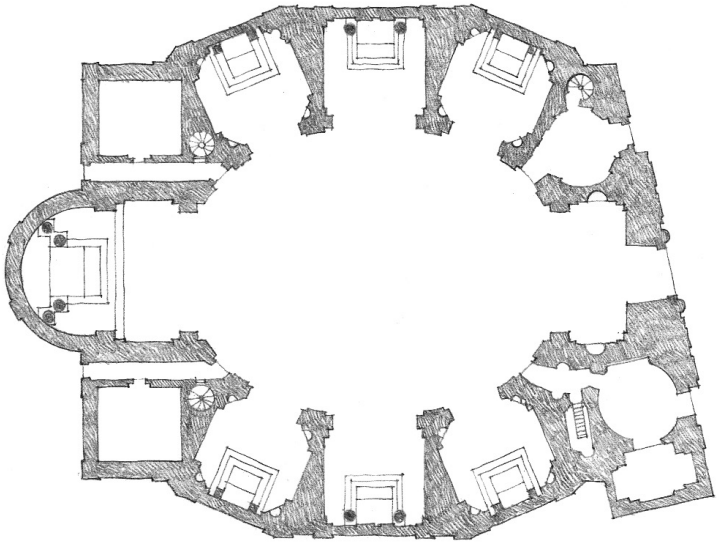


Temple on the Ilissus, Athens

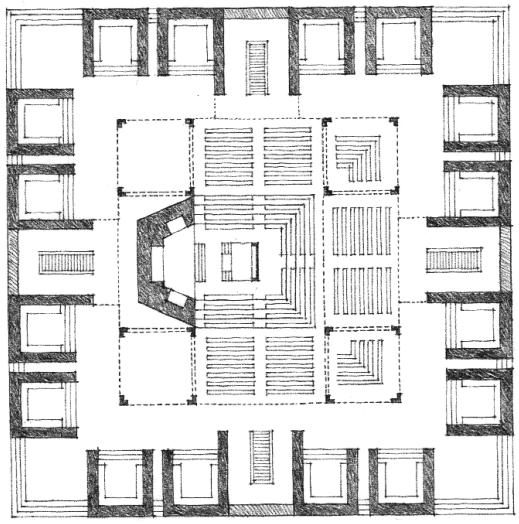
Plans of Greek Temples
5th–4th centuries B.C.

U-shaped enclosures of interior space have a specific orientation toward their open ends. These U-shaped enclosures can group themselves around a central space to form an introverted organization.

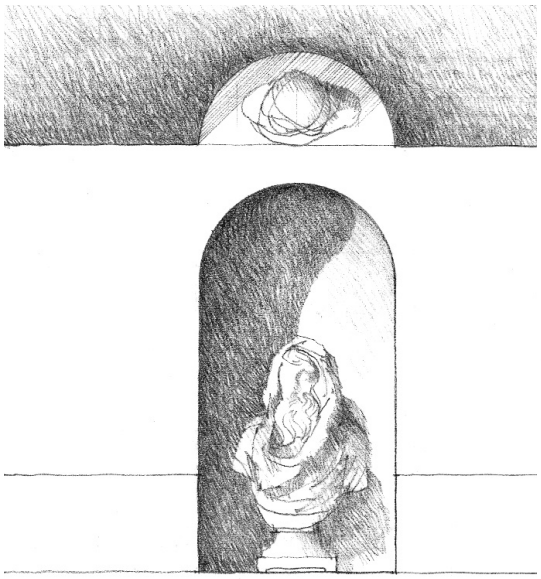
The Hotel for Students at Otaniemi, Finland, by Alvar Aalto, demonstrates the use of U-shaped enclosures to define the basic unit of space in double-loaded schemes for dormitories, apartments, and hotels. These units are extroverted. They turn their back on the corridor and orient themselves to the exterior environment.



Sketch of an Oval Church by Borromini, Genesis of San Carlo Alle Quattro Fontane

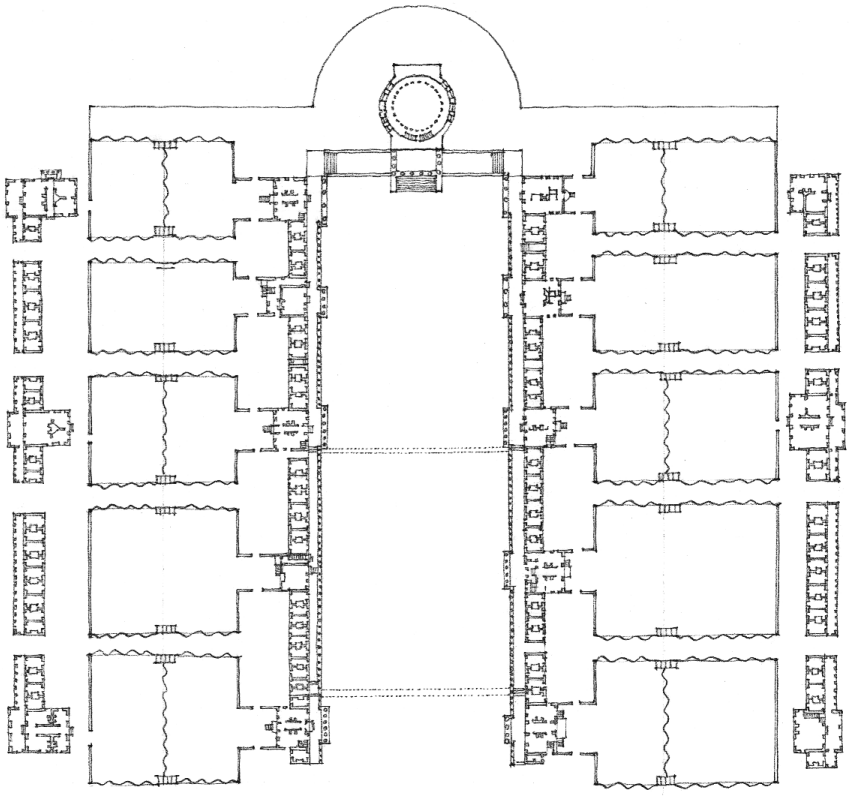


Hurva Synagogue (project), Jerusalem, 1968, Louis Kahn

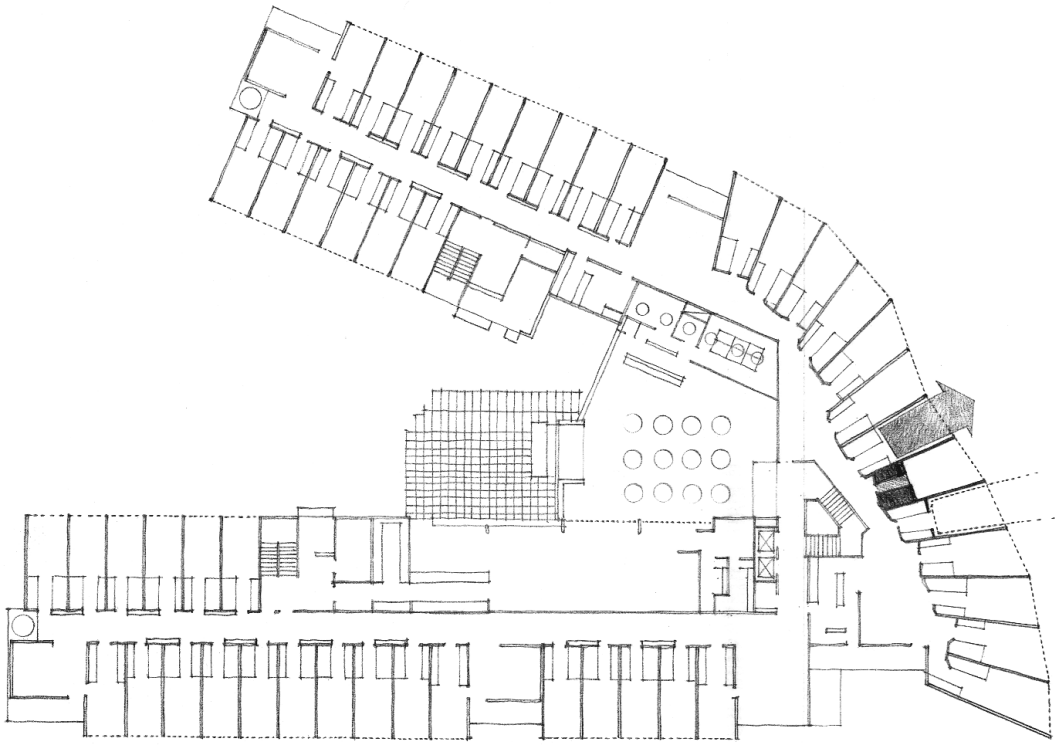


A niche in a wall

U-shaped enclosures of space can range in scale from a niche in the wall of a room, to a hotel or dormitory room, and on to an arcaded outdoor space that organizes an entire complex of buildings.

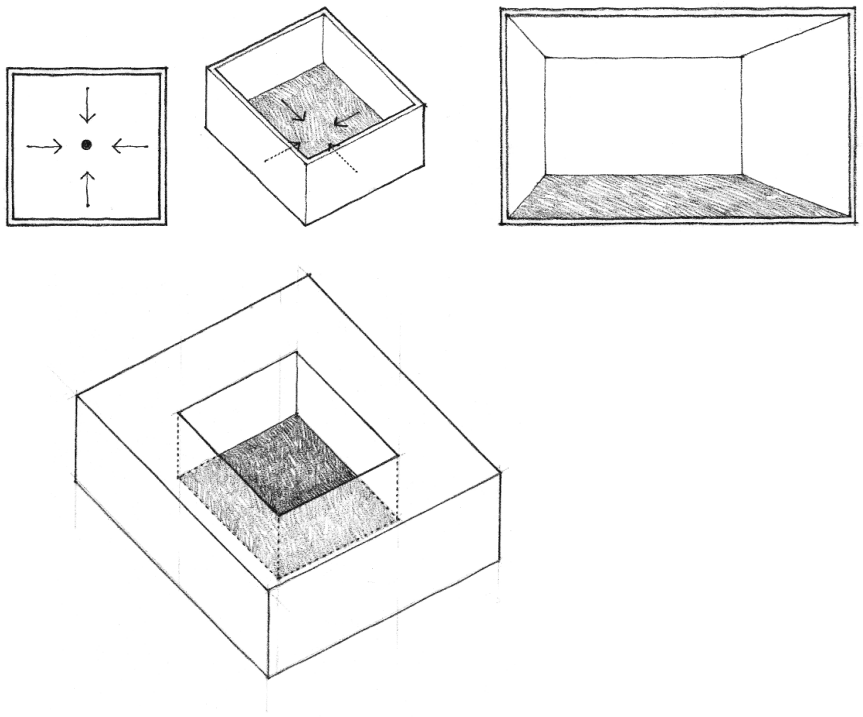


University of Virginia, Charlottesville, Virginia, 1817–1826, Thomas Jefferson with Thornton and Latrobe



Hotel for Students at Otaniemi, Finland, 1962–1966, Alvar Aalto

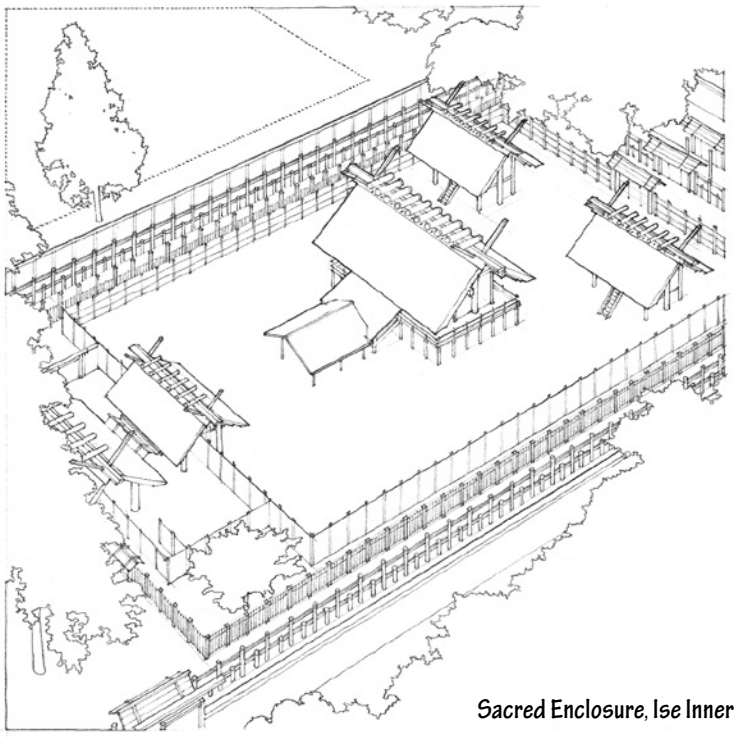
FOUR PLANES: CLOSURE

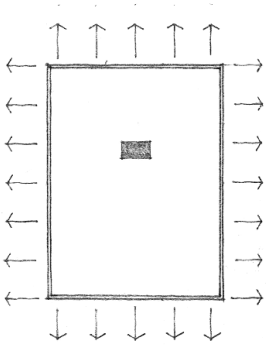


Four vertical planes encompassing a field of space is probably the most typical, and certainly the strongest, type of spatial definition in architecture. Since the field is completely enclosed, its space is naturally introverted. To achieve visual dominance within a space or become its primary face, one of the enclosing planes can be differentiated from the others by its size, form, surface articulation, or by the nature of the openings within it.

Well-defined, enclosed fields of space can be found in architecture at various scales, from a large urban square, to a courtyard or atrium space, to a single hall or room within a building complex. The examples on this and the following pages illustrate enclosed spatial fields in both urban and building-scale situations.

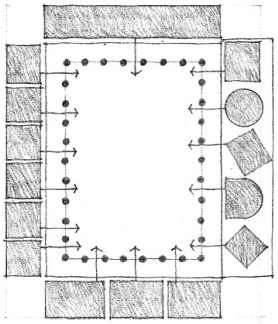
Historically, four planes have often been used to define a visual and spatial field for a sacred or significant building that stands as an object within the enclosure. The enclosing planes may be ramparts, walls, or fences that isolate the field and exclude surrounding elements from the precinct.

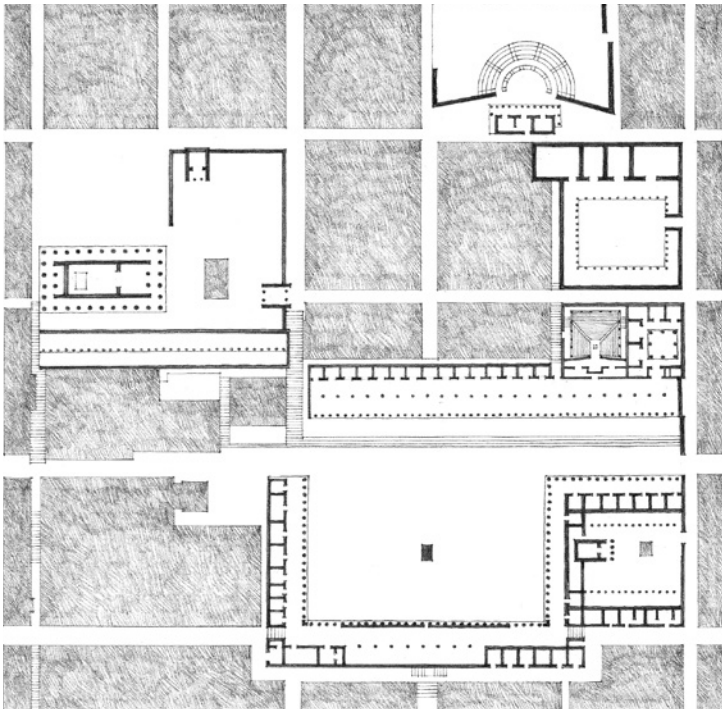




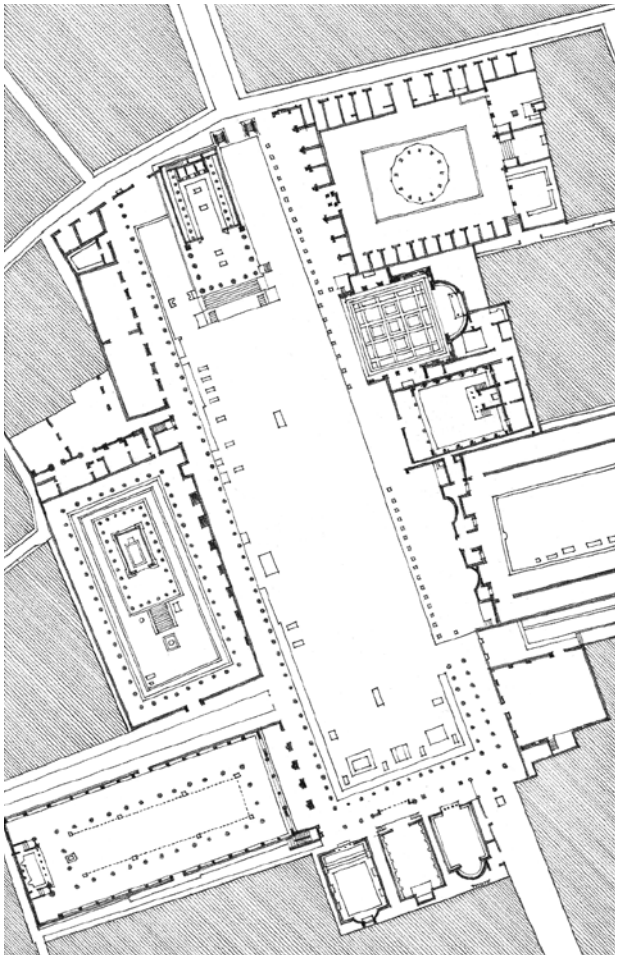
Sacred Enclosure, Ise Inner Shrine, Mie Prefecture, Japan, reconstructed every 20 years since A.D. 690.

In an urban context, a defined field of space can organize a series of buildings along its perimeter. The enclosure may consist of arcades or gallery spaces that promote the inclusion of surrounding buildings into their domain and activate the space they define.

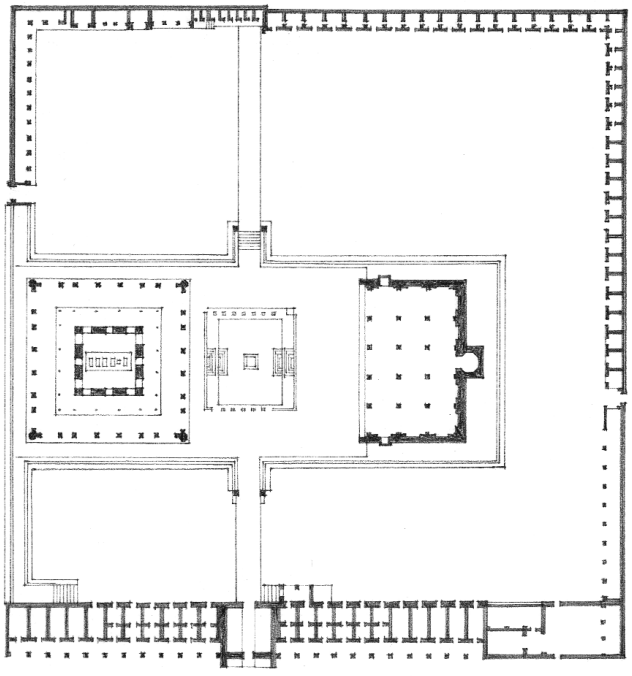




Plan of the **Agora at Priene** and its surroundings, 4th century B.C.

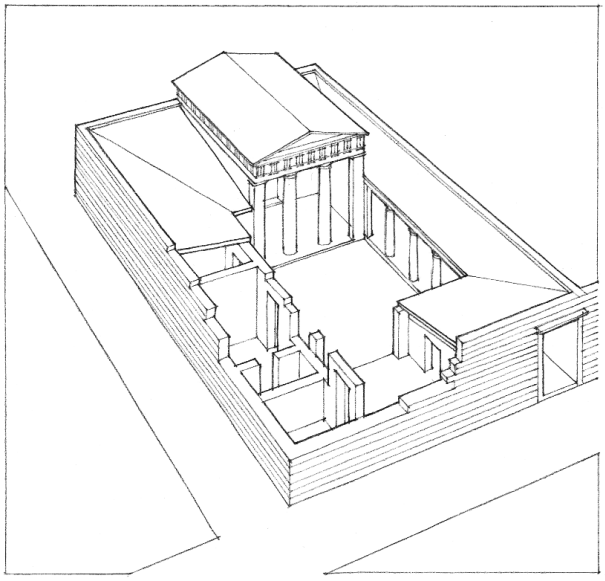


Forum at Pompeii, 2nd century B.C.

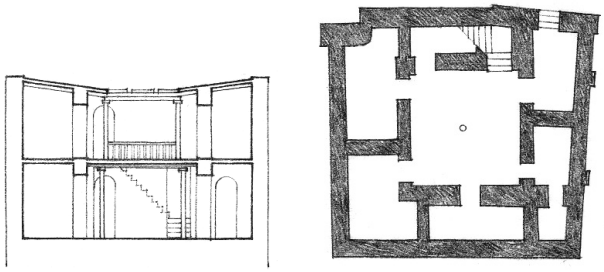


Ibrahim Rauza, Tomb of Sultan Ibrahim II, Bijapur, India, 1615, Malik Sandal

FOUR PLANES: CLOSURE

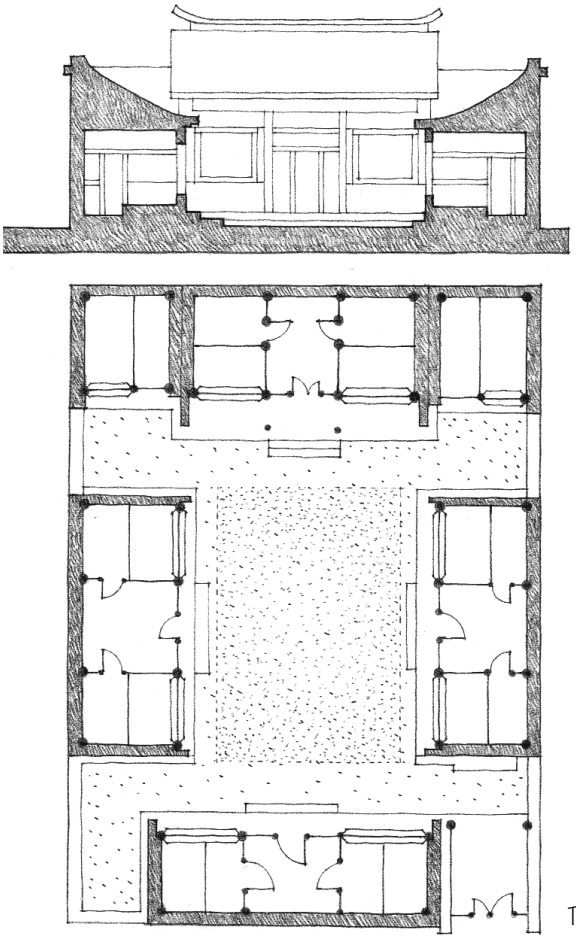


House No. 33, Priene, 3rd century B.C.

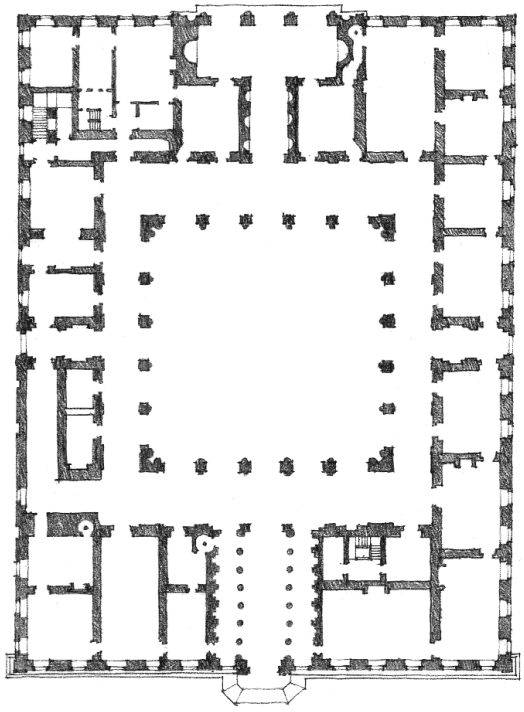


House, Ur of the Chaldees, *c.* 2000 B.C.

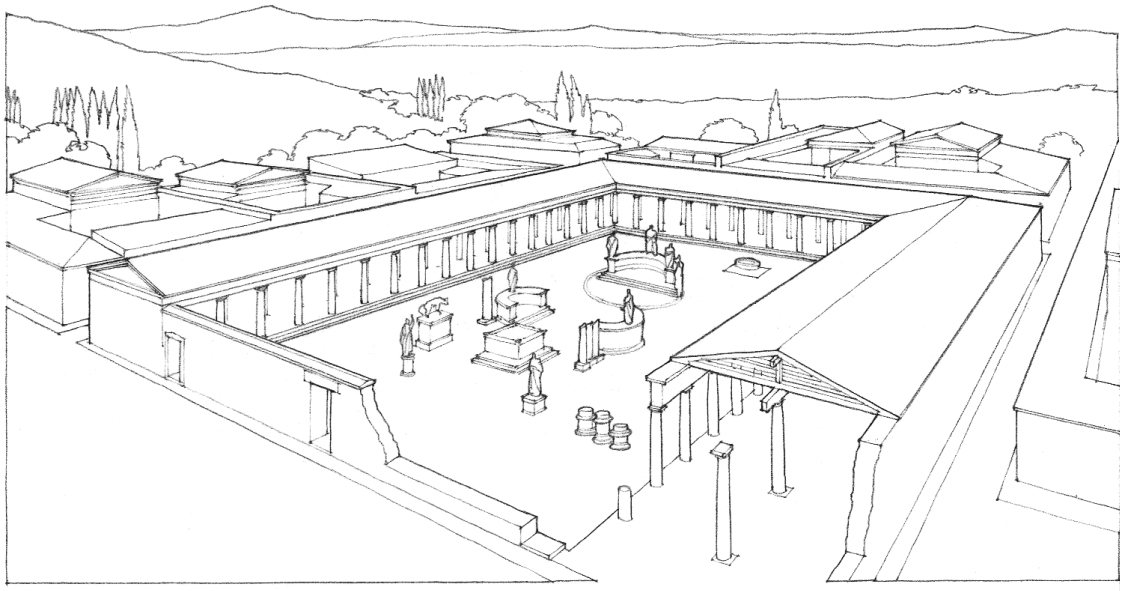
The examples on these two pages illustrate the use of enclosed volumes of space as ordering elements about which the spaces of a building can be clustered and organized. These organizing spaces can generally be characterized by their centrality, their clarity of definition, their regularity of form, and their dominating size. They are manifested here in the atrium spaces of houses, the arcaded cortile of an Italian palazzo, the enclosure of a Greek shrine, the courtyard of a Finnish town hall, and the cloister of a monastery.



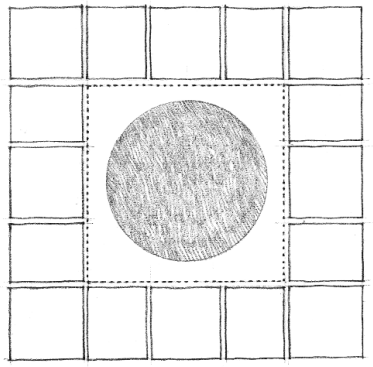
Traditional Chinese Patio House

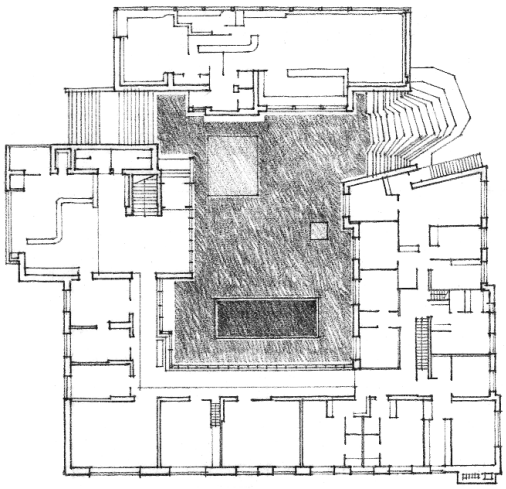


Palazzo Farnese, Rome, 1515, Antonio da Sangallo the Younger

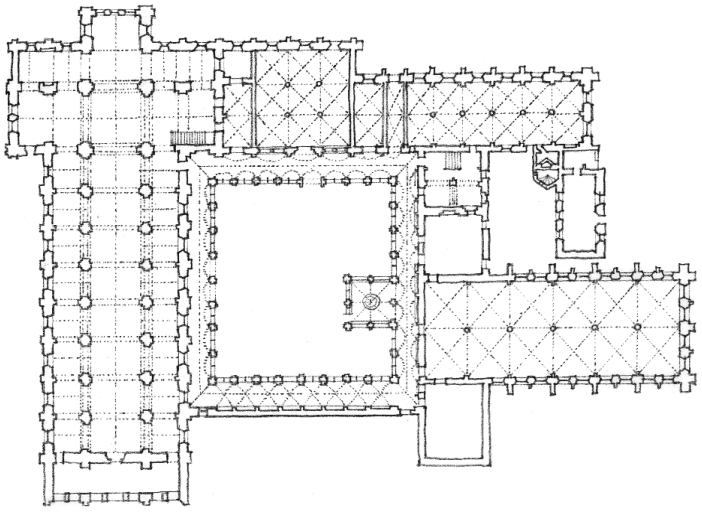


Enclosure of the **Shrine of Apollo Delphinios**, Miletus, c. 2nd century B.C.



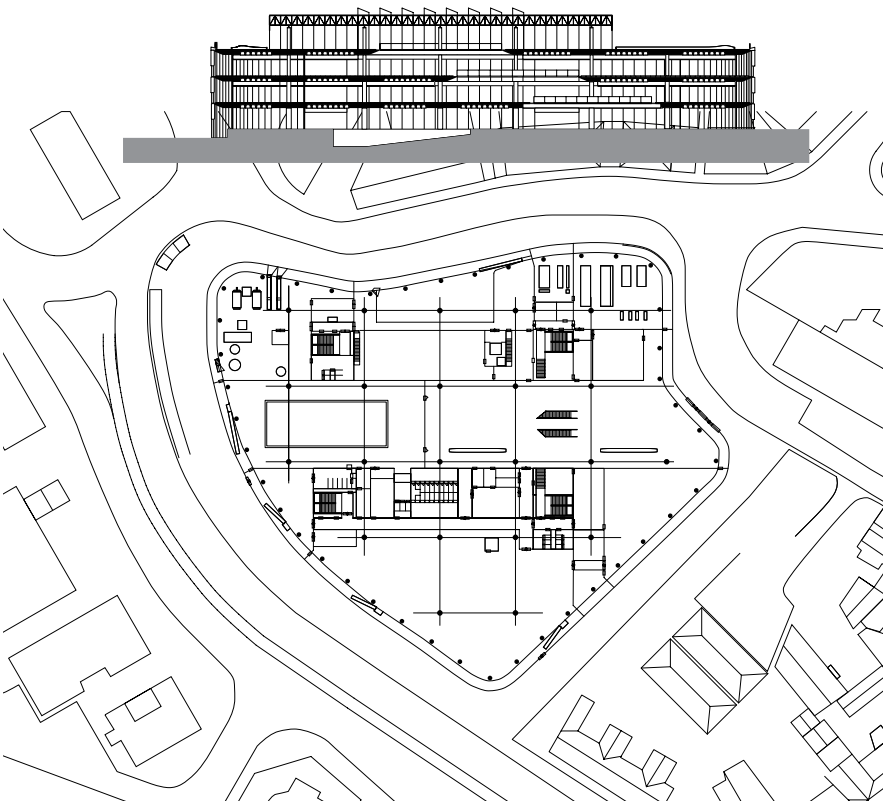


Town Hall, **Säynätsalo**, Finland, 1950–1952, Alvar Aalto



Fontenay Abbey, Burgundy, France, c. 1139

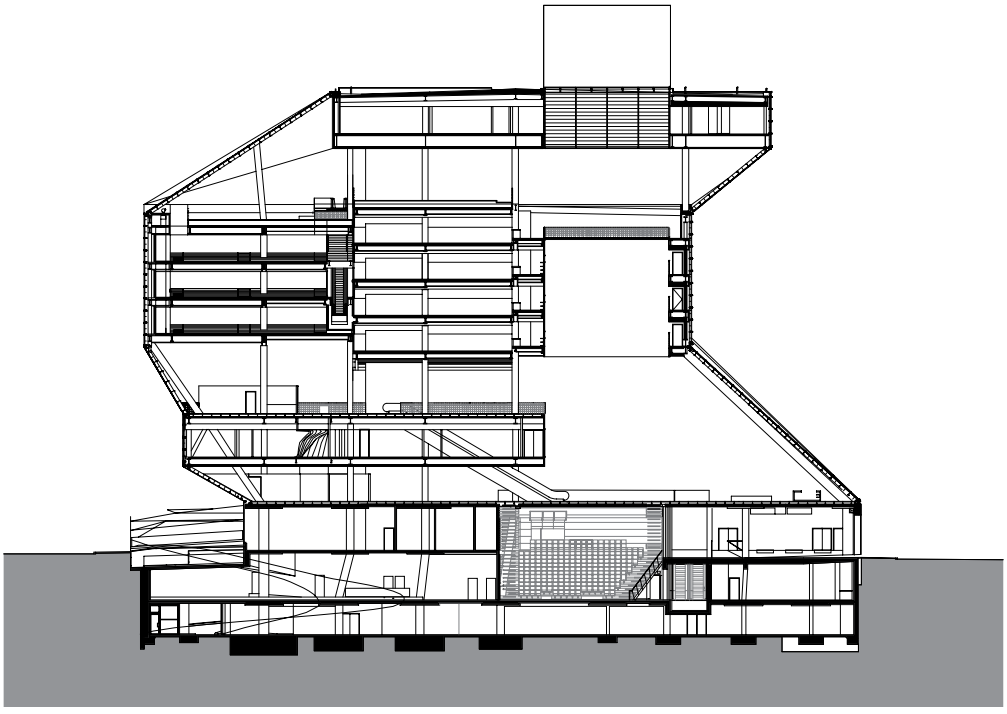
FOUR PLANES: ENCLOSURE



Willis, Faber & Dumas Headquarters, Ipswich, England, 1971–1975, Foster + Partners

How the overhead or roof plane can dominate the form of a building is illustrated on pages 147–149. In contrast, other buildings can be seen to be dominated by the form of their exterior, enclosing wall planes. Exterior walls determine to a great extent the visual character of a building, whether they have the weight and opacity of load-bearing walls, the lightness and transparency of nonbearing curtain walls supported by a structural framework of columns and beams, or a combination of both.

The transition from bearing-wall constructions to frame structures have given rise to new forms that go beyond the timeless elements of basic statics—the columns, beams, and load-bearing walls of stable constructions that are fixed in time and space. The rational forms of rectilinear geometry and the rule of the vertical have been revised, both statically and optically, by the development of irregular structures that rely on tension and friction rather than pressure. We can see these new forms as they mimic topography, orient themselves toward views, embrace sunlight, and turn away from cold winds and stormy weather.



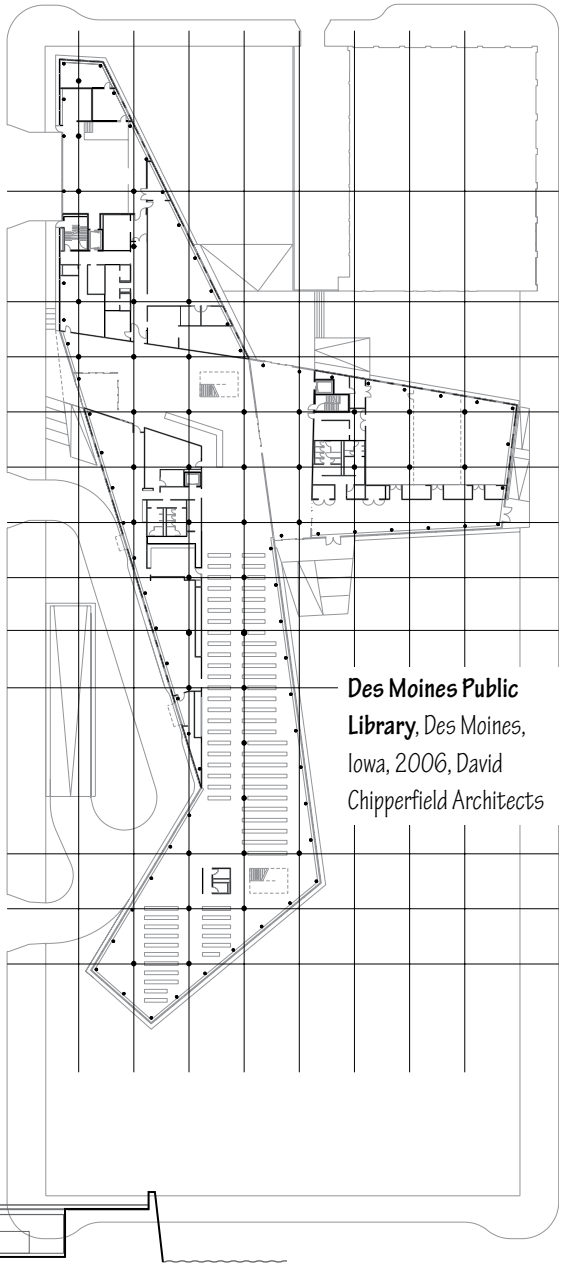
Seattle Public Library, Seattle, Washington, 2004, OMA

The evolution of materials and technology for separating the skin of a building from its structure has also played a major role in the development of building forms.

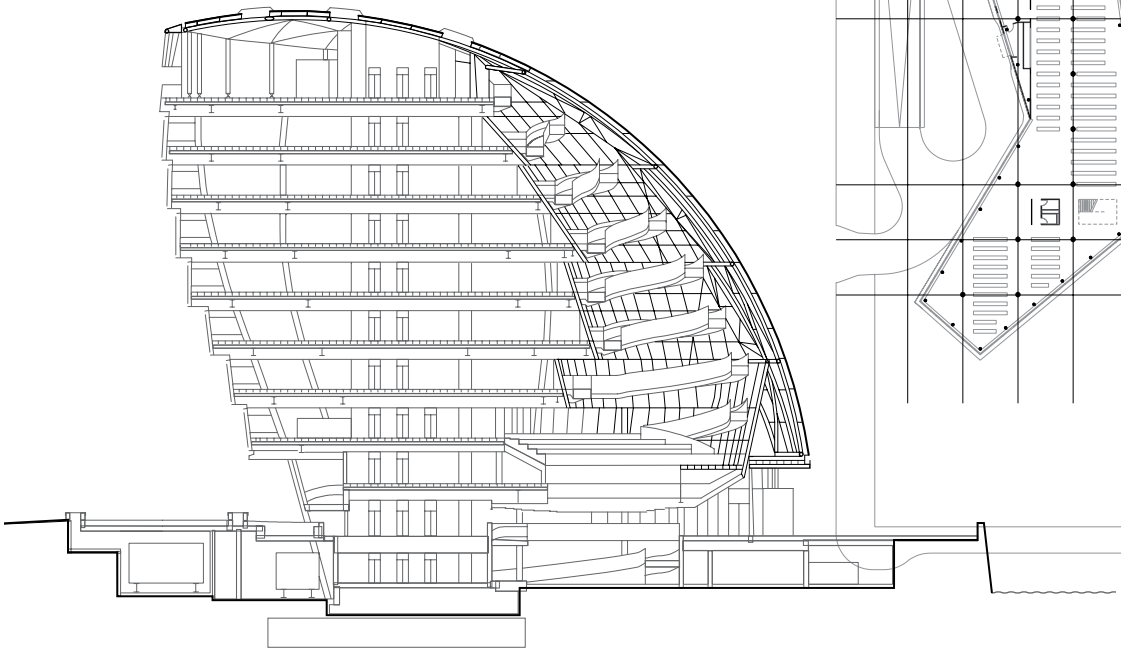
Structural glass facades integrate structure and cladding to provide maximum transparency in buildings. While their forms may vary, the translucent panels typically span from floor to floor and are supported by structural systems that are exposed and distinct from the building's primary structure.

Many of the structural systems use trusses or trussed supports, which may slope inward or outward, or follow a curved geometry in plan or section. Some use glass fins set perpendicular to the glass facade to provide lateral support.

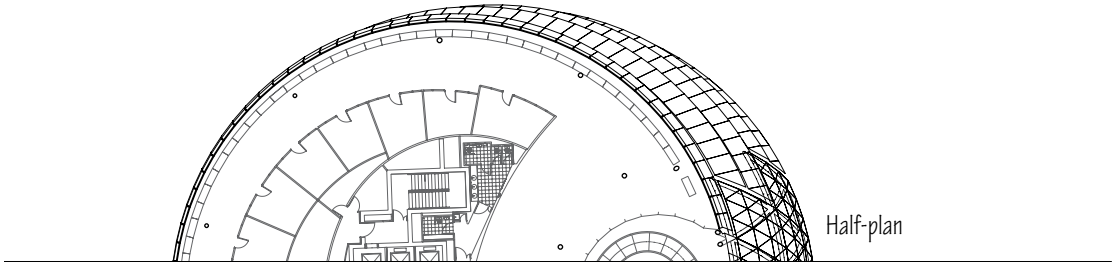
Gridshells are form-active structures that derive their strength from their double-curved surface geometry. The system uses a network of in-plane prestressed cables to provide stability and shear resistance to the thin shell grid. Vaulted, domed, and other double-curved configurations can be used in vertical and overhead applications as well as to form complete building enclosures.



Des Moines Public Library, Des Moines, Iowa, 2006, David Chipperfield Architects

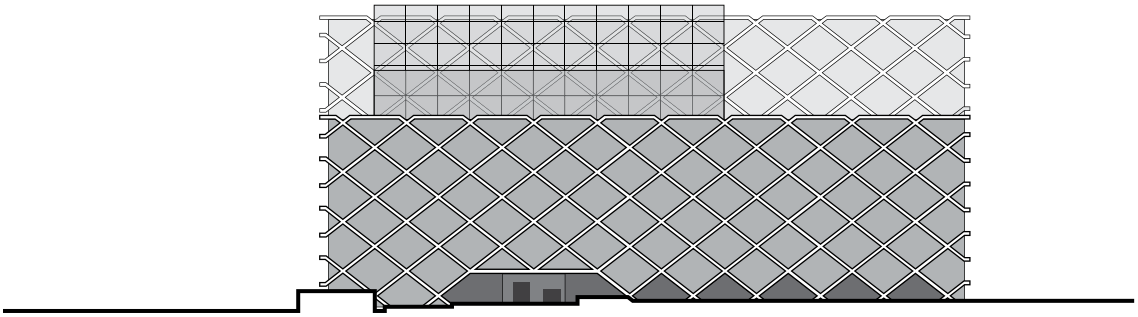


London City Hall, London, England, 1998–2003, Foster + Partners

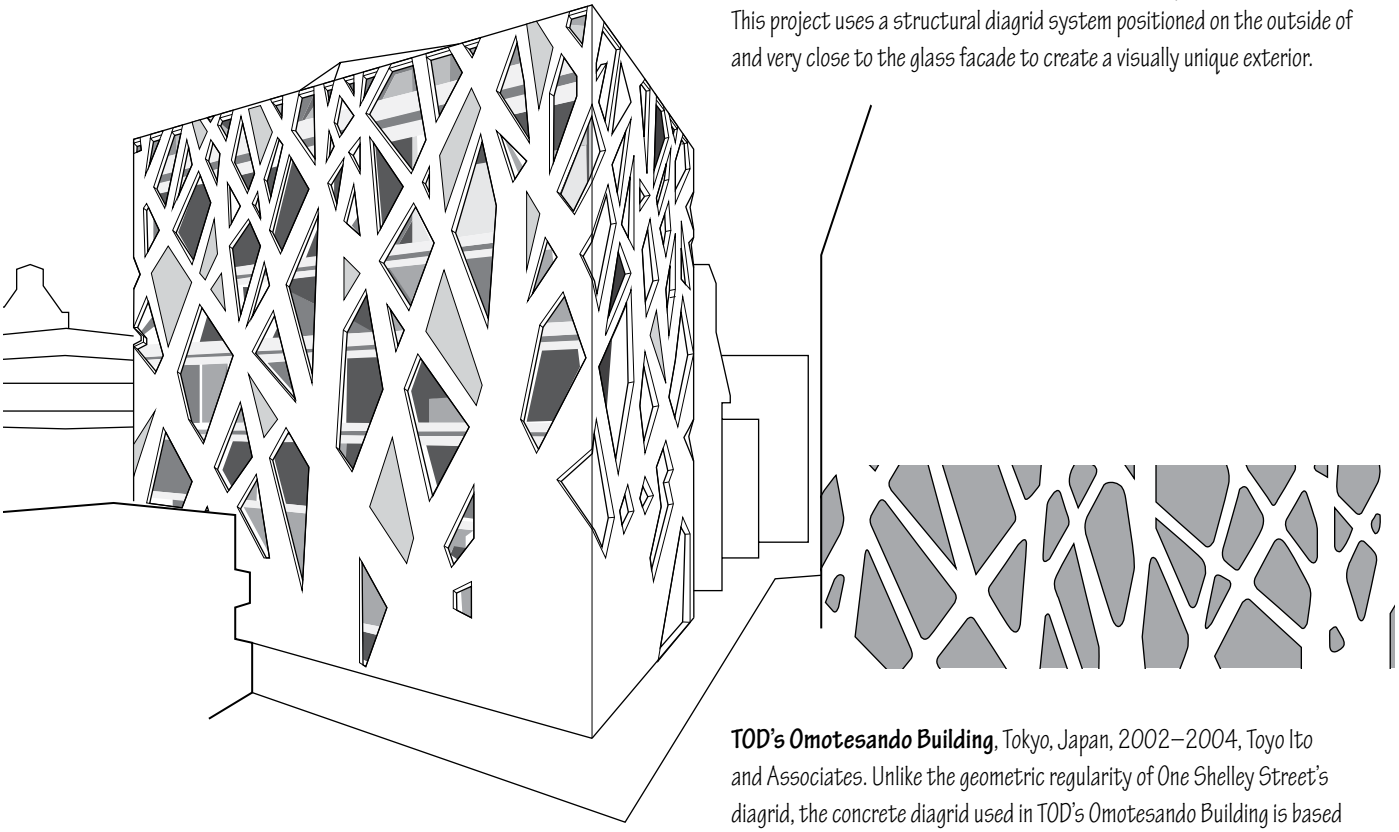


Half-plan

Diagrid structures refer to networks of intersecting members connected at specially jointed nodes to create a diagonal grid across a building surface. The diagonal members are capable of carrying both gravity and lateral loads through triangulation, which results in a relatively uniform load distribution. This exoskeletal framework allows for the possible reduction in the number of internal supports, saving on space and building materials and providing for greater flexibility in interior layouts. Also, because each diagonal can be viewed as providing a continuous load path to the ground, the number of possible load paths in case of a localized structural failure results in a high degree of redundancy.



One Shelley Street, Sydney, Australia, 2009, Fitzpatrick + Partners. This project uses a structural diagrid system positioned on the outside of and very close to the glass facade to create a visually unique exterior.

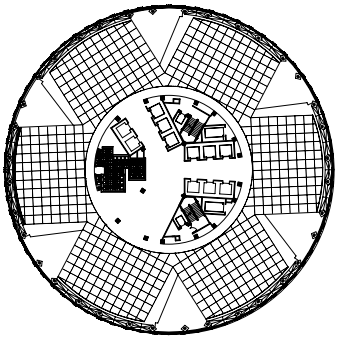


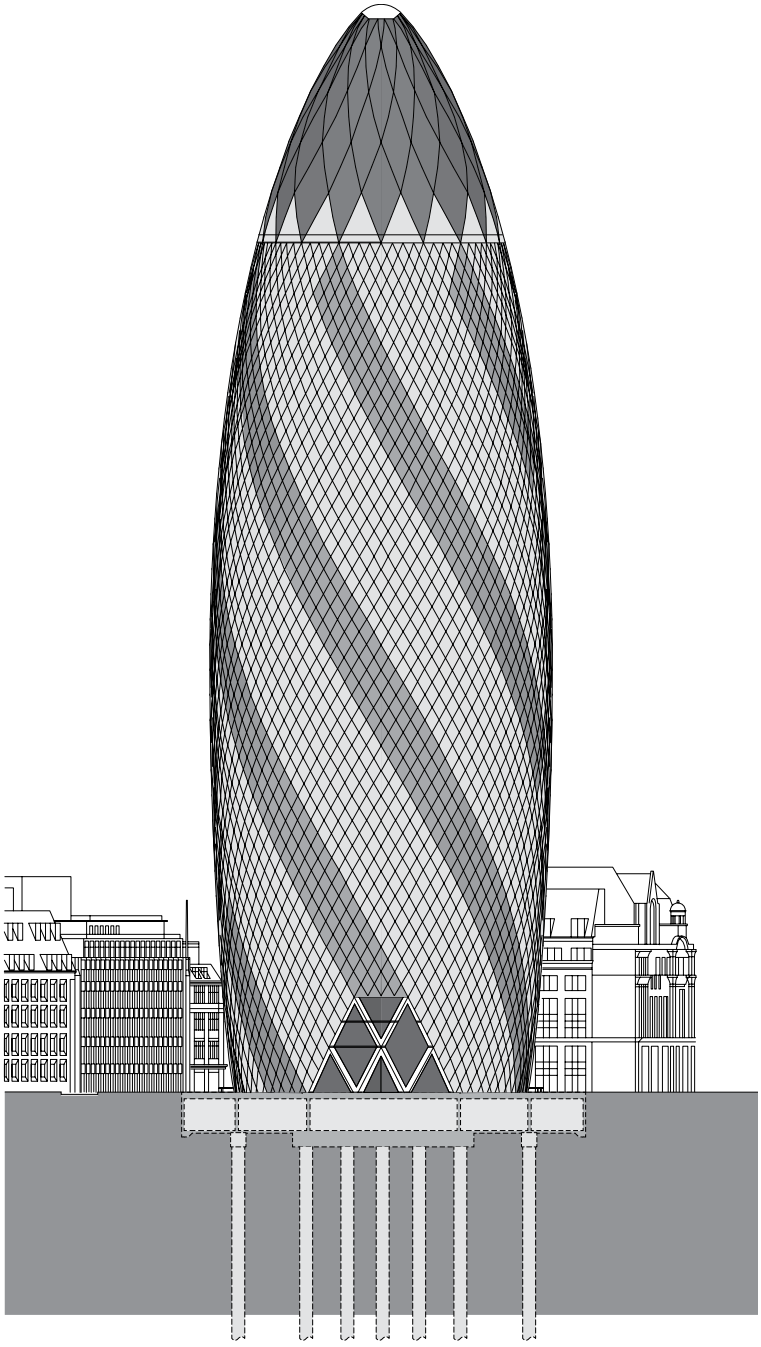
TOD's Omotesando Building, Tokyo, Japan, 2002–2004, Toyo Ito and Associates. Unlike the geometric regularity of One Shelley Street's diagrid, the concrete diagrid used in TOD's Omotesando Building is based on a pattern of overlapping tree silhouettes that mimic the branch structure of nearby elm trees. Similar to the growth pattern of trees, the diagrid members get thinner and more numerous with a higher ratio of openings as you move up higher in the building.

The various forms of diagrid structures have been made possible through digital technologies that help us to conceive of and make visible complex three-dimensional constructions and compositions. 3D modeling and CAD software enable us to develop, describe, and fabricate the components to realize these constructions. Many of these creations would be difficult, if not impossible, to do by hand. This is especially true of the calculations necessary to determine the structural requirements for the individual members of a diagrid system.

3D modeling and CAD software have not only the computational capability to calculate the structural requirements for each member but also the means with 3D printers to fabricate the components, many of which are not identical for assembly on site.

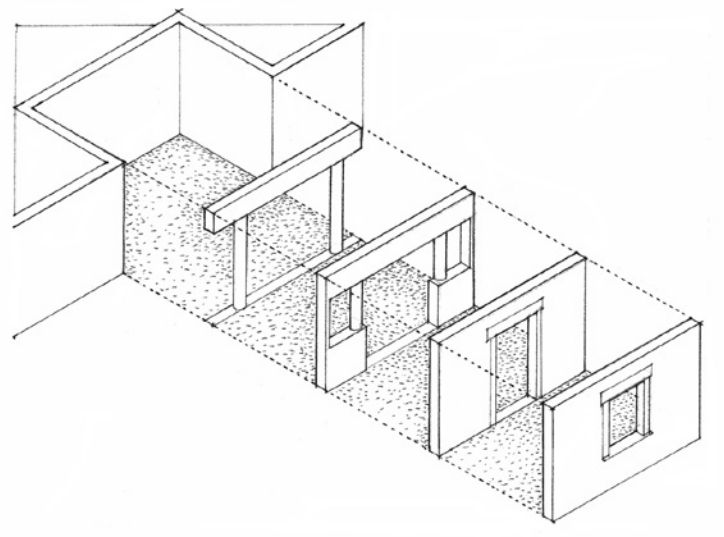
Perimeter hoops resist the horizontal forces at each node level where the diagonal columns intersect. As with dome structures, the hoops in the upper region are in compression while those at the middle and lower levels are subject to significant tensile forces. The hoops also serve to transform the diagrid into a very stiff triangulated shell, freeing the interior core from the need to resist lateral wind forces.





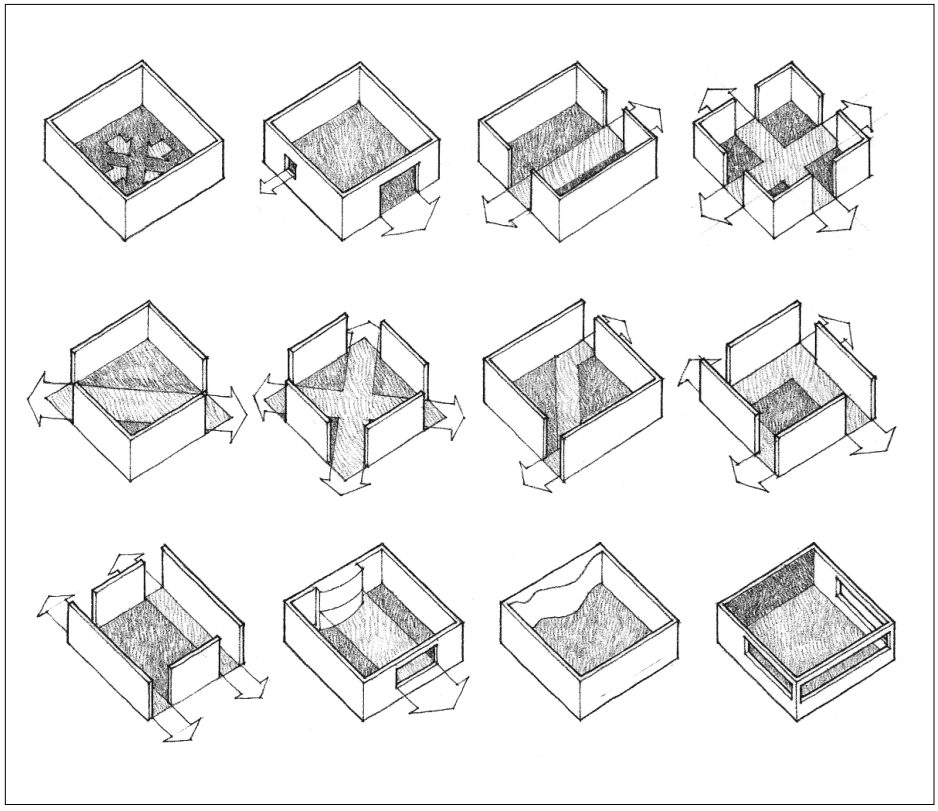
30 St. Mary Axe, London, UK, 2001–2003, Foster + Partners. Informally known as The Gherkin and previously, the Swiss Re Building, this skyscraper is an iconic symbol in London's financial district. The shape of the tower was partially influenced by the need to have a smooth flow of wind around the building and minimize its impact on the local wind environment. Across this curved surface the diagrid structure is formed by generating a pattern of intersecting diagonals spiraling in two directions.

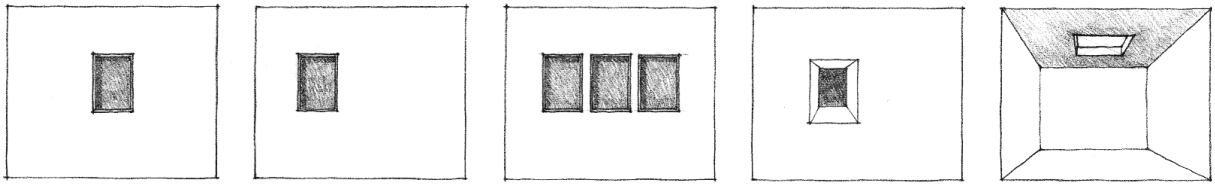
OPENINGS IN SPACE-DEFINING ELEMENTS



No spatial or visual continuity is possible with adjacent spaces without openings in the enclosing planes of a spatial field. Doors offer entry into a room and influence the patterns of movement and use within it. Windows allow light to penetrate the space and illuminate the surfaces of a room, offer views from the room to the exterior, establish visual relationships between the room and adjacent spaces, and provide for the natural ventilation of the space. While these openings provide continuity with adjacent spaces, they can, depending on their size, number, and location, also begin to weaken the enclosure of the space.

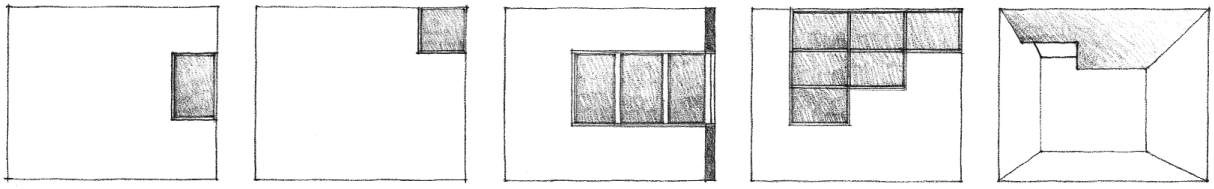
The following section of this chapter focuses on enclosed spaces at the scale of a room, where the nature of the openings within the room's enclosure is a major factor in determining the quality of its space.





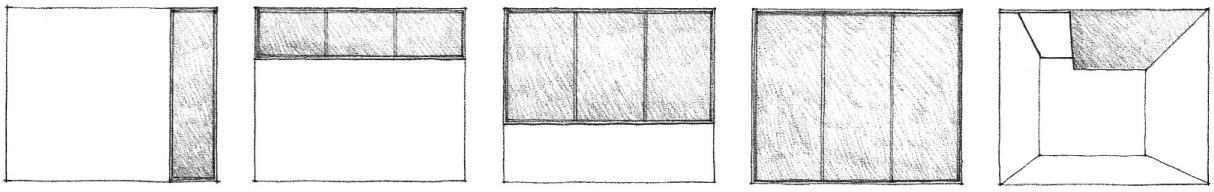
Centered | Off-center | Grouped | Deep-set | Skylight

Within Planes An opening can be located wholly within a wall or ceiling plane and be surrounded on all sides by the surface of the plane.



Along one edge | Along two edges | Turning a corner | Grouped | Skylight

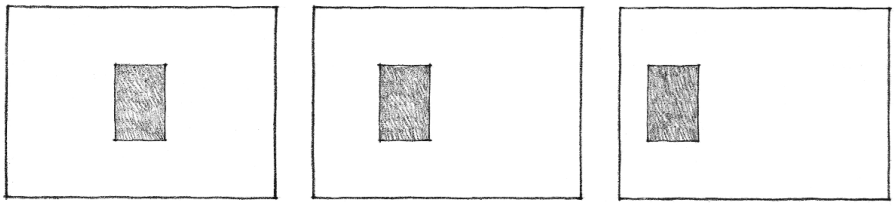
At Corners An opening can be located along one edge or at a corner of a wall or ceiling plane. In either case, the opening will be at a corner of a space.



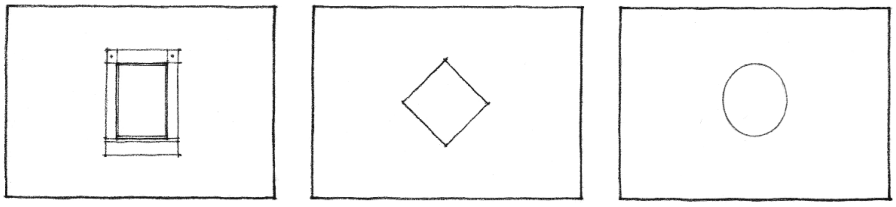
Vertical | Horizontal | Three-quarter opening | Window-wall | Skylight

Between Planes An opening can extend vertically between the floor and ceiling planes or horizontally between two wall planes. It can grow in size to occupy an entire wall of a space.

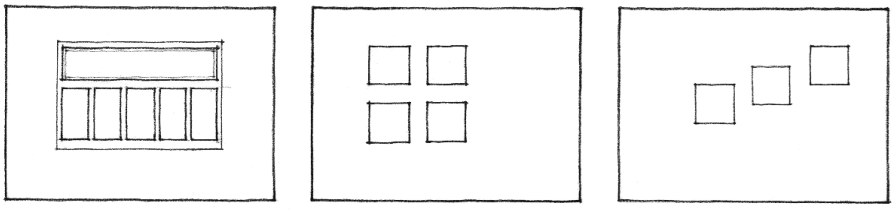
OPENINGS WITHIN PLANES



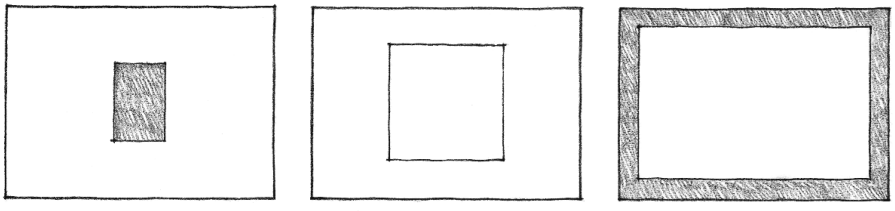
An opening located wholly within a wall or ceiling plane often appears as a bright figure on a contrasting field or background. If centered within the plane, the opening will appear stable and visually organize the surface around it. Moving the opening off-center will create a degree of visual tension between the opening and the edges of the plane toward which it is moved.



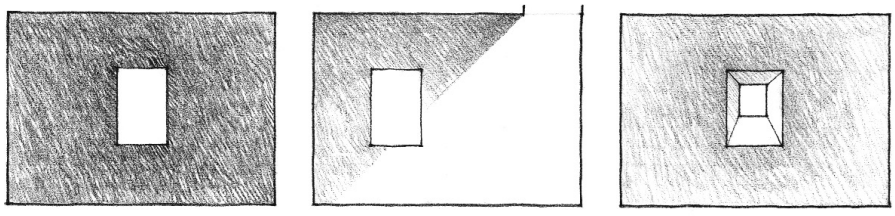
The shape of the opening, if similar to the shape of the plane in which it is located, will create a redundant compositional pattern. The shape or orientation of the opening may contrast with the enclosing plane to emphasize its individuality as a figure. The singularity of the opening may be visually reinforced with a heavy frame or articulated trimwork.



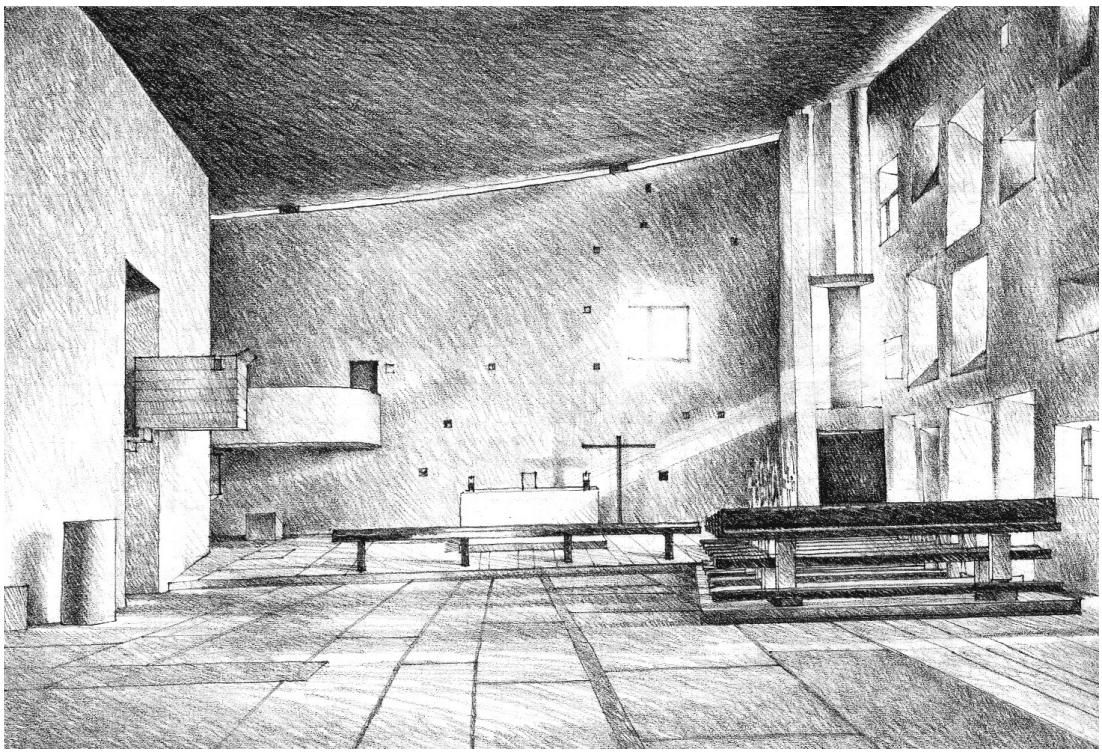
Multiple openings may be clustered to form a unified composition within a plane, or be staggered or dispersed to create visual movement along the surface of the plane.



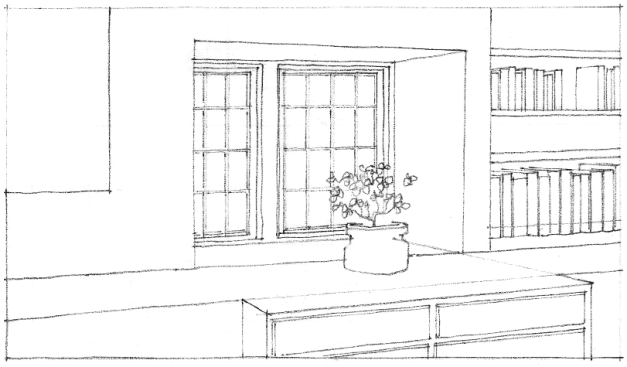
As an opening within a plane increases in size, it will at some point cease to be a figure within an enclosing field and become instead a positive element in itself, a transparent plane bounded by a heavy frame.

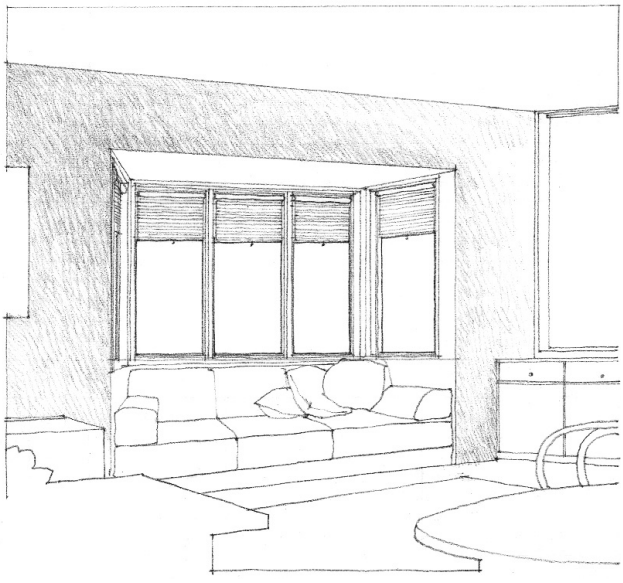


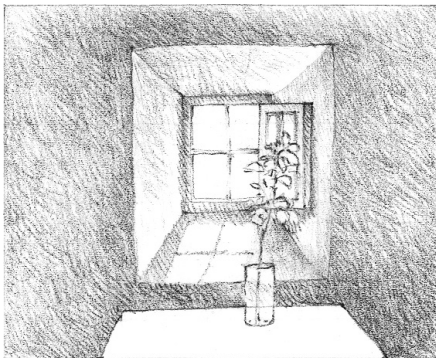
Openings within planes naturally appear brighter than their adjacent surfaces. If the contrast in brightness along the edges of the openings becomes excessive, the surfaces can be illuminated by a second light source from within the space, or a deep-set opening can be formed to create illuminated surfaces between the opening and the surrounding plane.

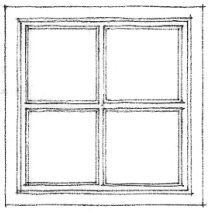


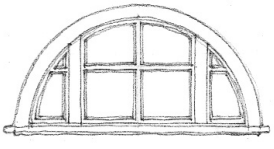
Chapel space, **Notre Dame Du Haut**, *Ronchamp, France, 1950–1955, Le Corbusier*



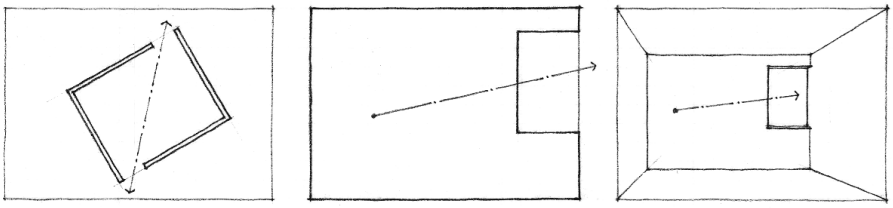


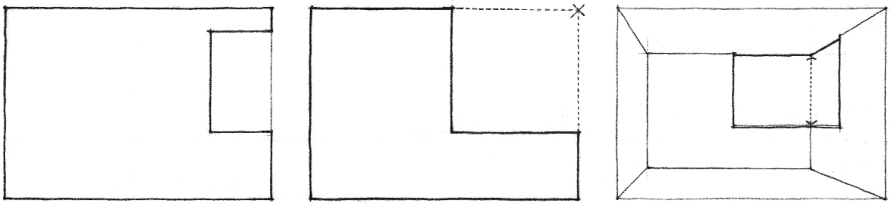


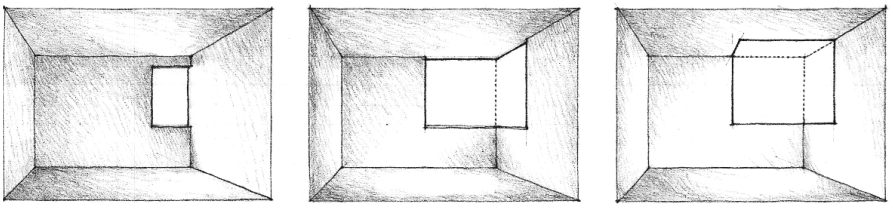


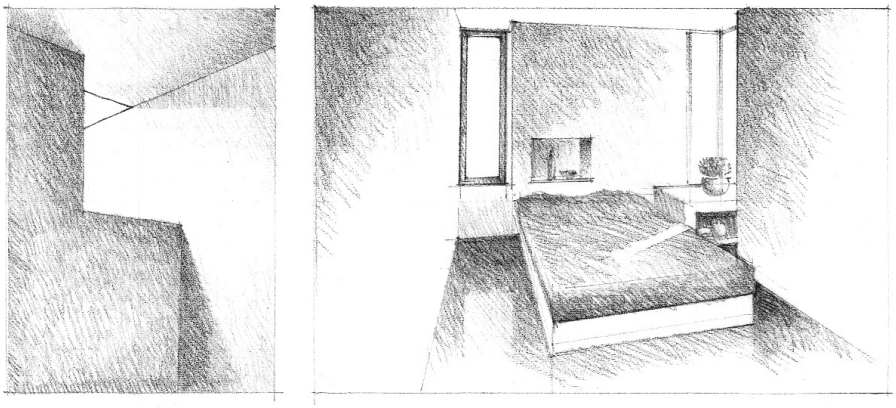


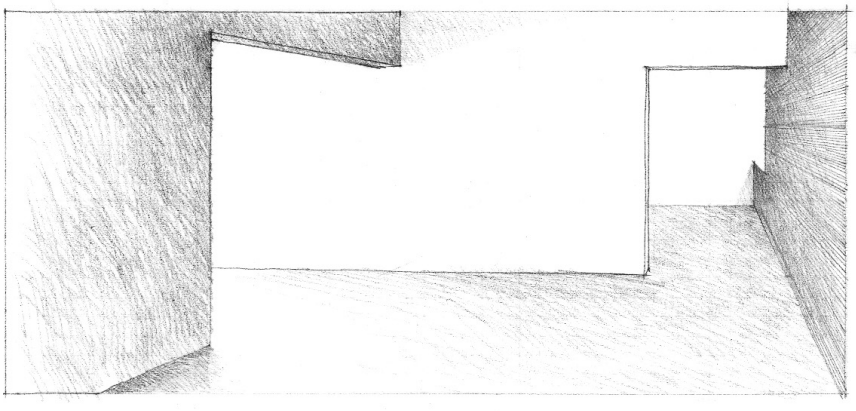
OPENINGS AT CORNERS









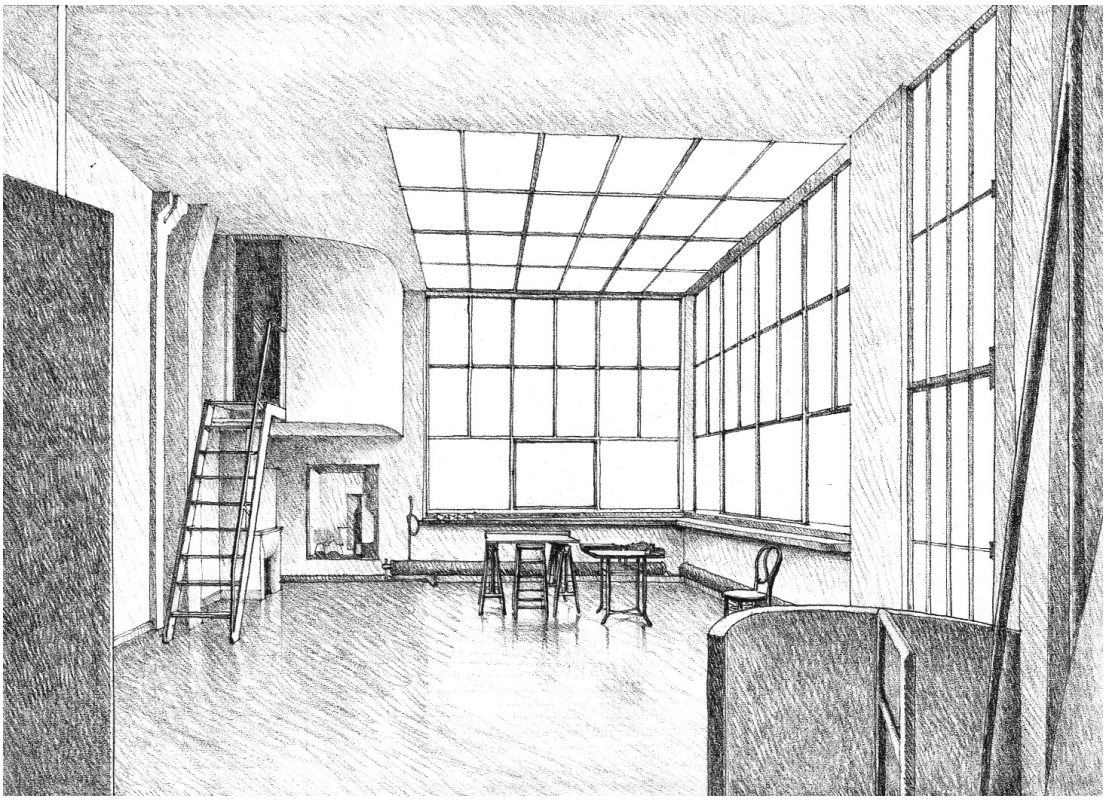


Openings that are located at corners give a space and the planes in which they are located a diagonal orientation. This directional effect may be desirable for compositional reasons, or the corner opening may be established to capture a desirable view or brighten a dark corner of a space.

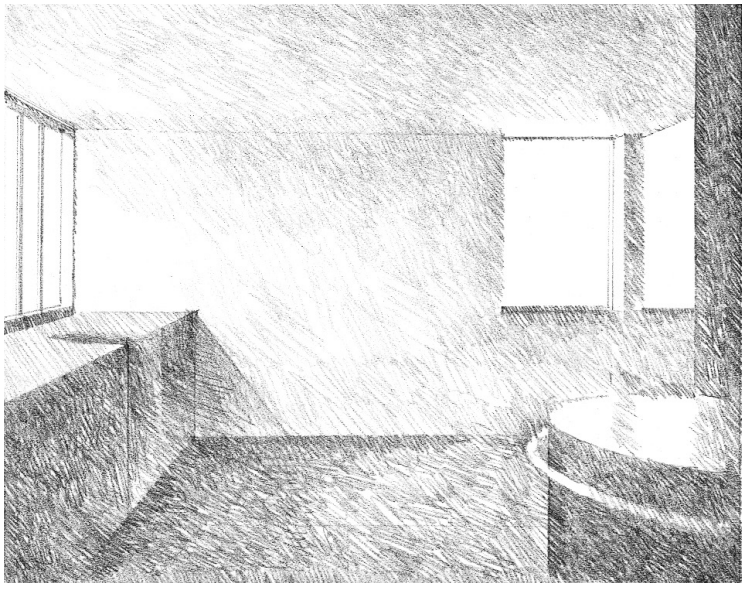
A corner opening visually erodes the edges of the plane in which it is located and articulates the edge of the plane adjacent and perpendicular to it. The larger the opening, the weaker will be the definition of the corner. If the opening were to turn the corner, the angle of the space would be implied rather than real and the spatial field would extend beyond its enclosing planes.

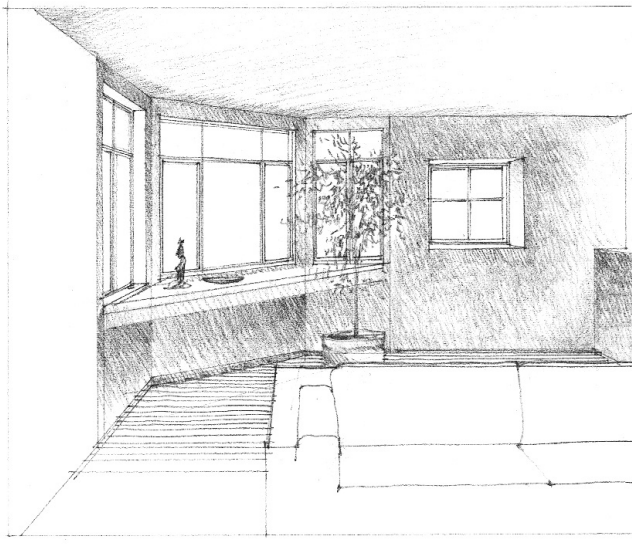
If openings are introduced between the enclosing planes at all four corners of a space, the individual identity of the planes will be reinforced and diagonal or pinwheel patterns of space, use, and movement will be encouraged.

The light that enters a space through a corner opening washes the surface of the plane adjacent and perpendicular to the opening. This illuminated surface itself becomes a source of light and enhances the brightness of the space. The level of illumination can be enhanced further by turning the corner with the opening or adding a skylight above the opening.

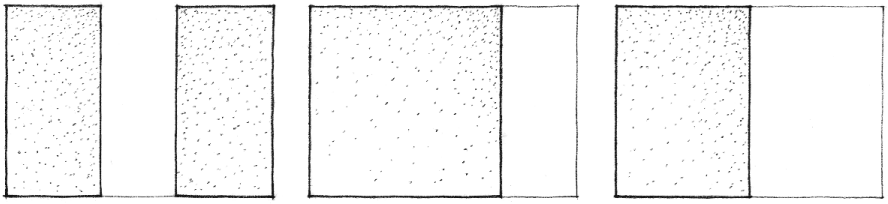


Studio, **Amédée Ozenfant House**, Paris, 1922–1923, Le Corbusier

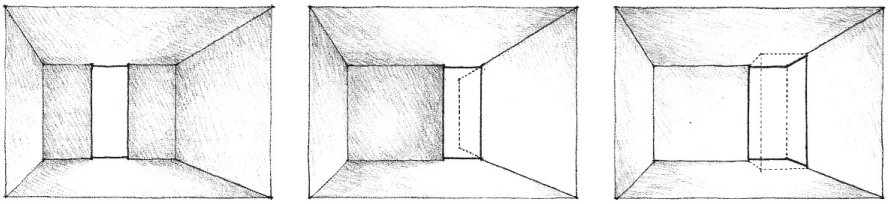




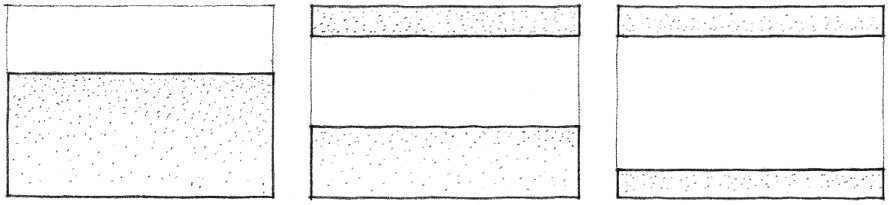
OPENINGS BETWEEN PLANES



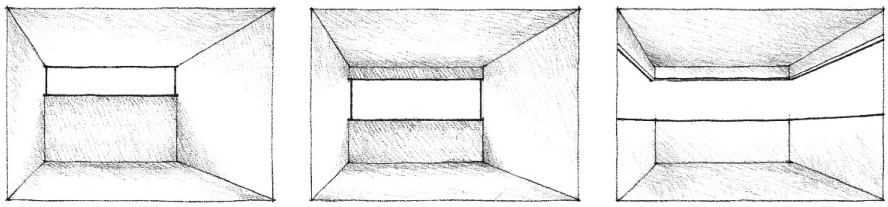
A vertical opening that extends from the floor to the ceiling plane of a space visually separates and articulates the edges of the adjacent wall planes.



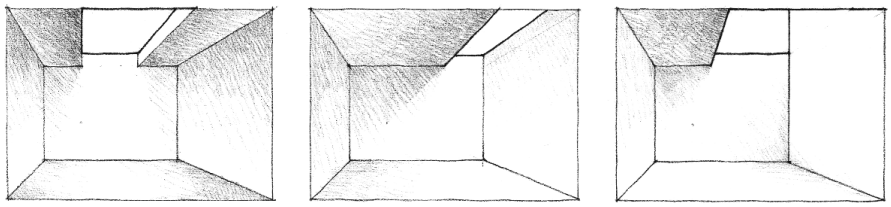
If located at a corner, the vertical opening will erode the definition of the space and allow it to extend beyond the corner to the adjacent space. It will also allow incoming light to wash the surface of the wall plane perpendicular to it and articulate the primacy of that plane in the space. If allowed to turn the corner, the vertical opening will further erode the definition of the space, allow it to interlock with adjacent spaces, and emphasize the individuality of the enclosing planes.



A horizontal opening that extends across a wall plane will separate it into a number of horizontal layers. If the opening is not very deep, it will not erode the integrity of the wall plane. If, however, its depth increases to the point where it is greater than the bands above and below it, then the opening will become a positive element bounded at its top and bottom by heavy frames.

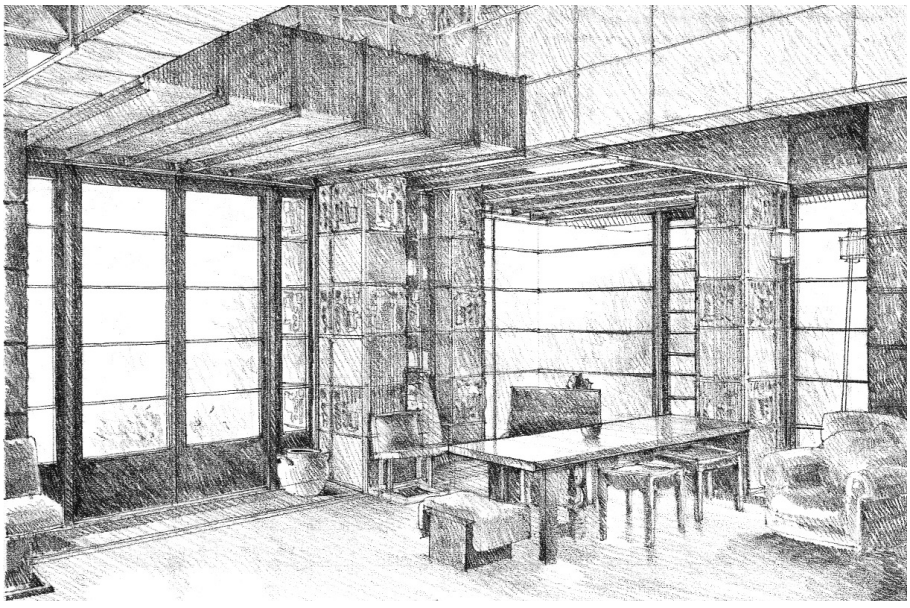


Turning a corner with a horizontal opening reinforces the horizontal layering of a space and broadens the panoramic view from within the space. If the opening continues around the space, it will visually lift the ceiling plane from the wall planes, isolate it, and give it a feeling of lightness.



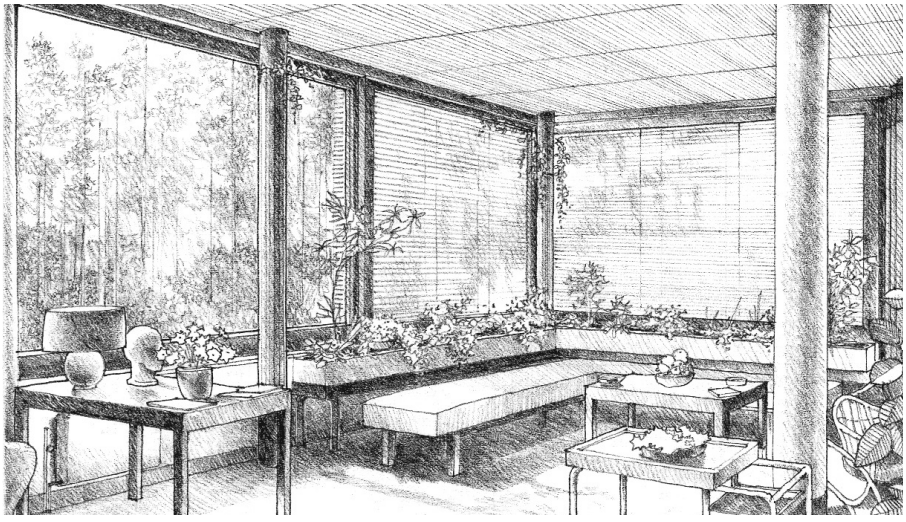
Locating a linear skylight along the edge where a wall and ceiling plane meet allows incoming light to wash the surface of the wall, illuminate it, and enhance the brightness of the space. The form of the skylight can be manipulated to capture direct sunlight, indirect daylight, or a combination of both.

Living Room, **Samuel Freeman House**, Los Angeles, California, 1924, Frank Lloyd Wright



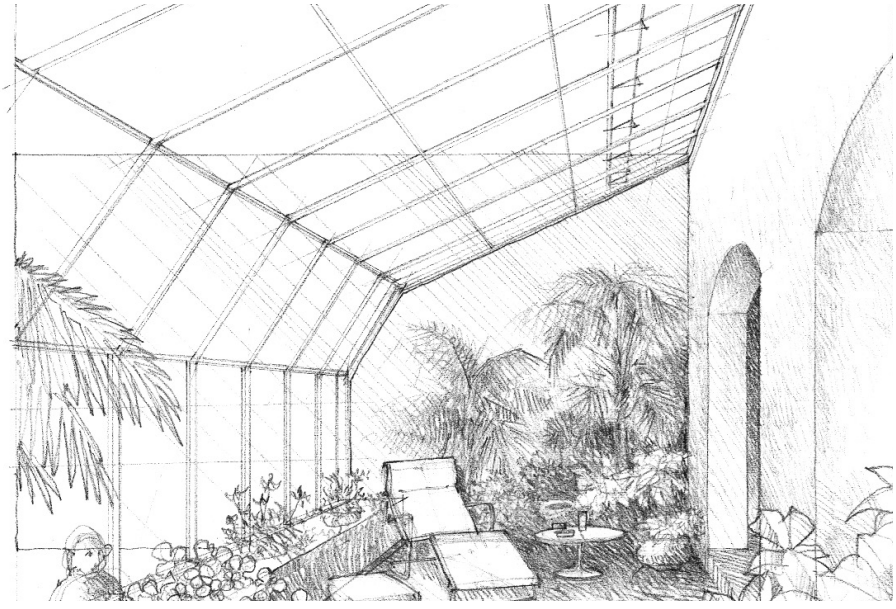
Window-walls offer more expansive views and permit a greater amount of daylight to penetrate a space than any of the previous examples of openings. If they are oriented to capture direct sunlight, sun-shading devices may be necessary to reduce glare and excessive heat gain within the space.

While a window-wall weakens the vertical boundaries of a space, it creates the potential for visually expanding the space beyond its physical boundaries.

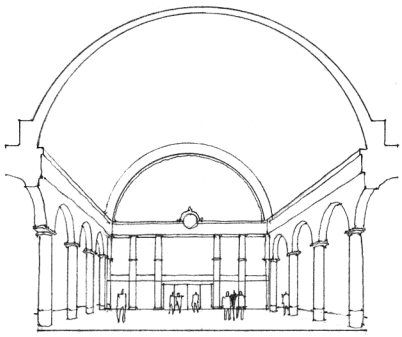


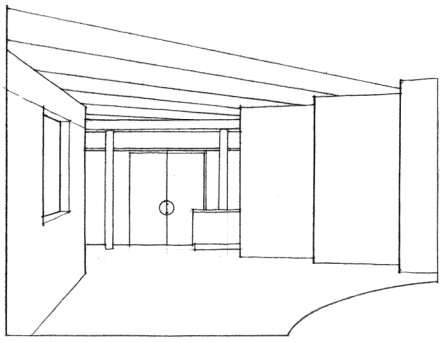
Living Room, **Villa Mairea**, Noormarkku, Finland, 1938–1939, Alvar Aalto

Combining a window-wall with a large skylight overhead creates a sunroom or greenhouse space. The boundaries between inside and outside, defined by the linear members of a frame, become obscure and tenuous.

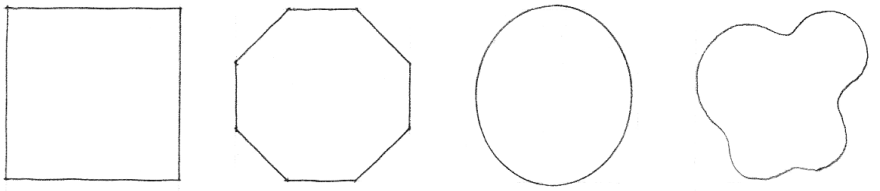


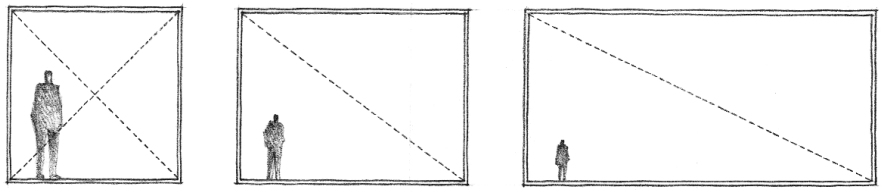
QUALITIES OF ARCHITECTURAL SPACE

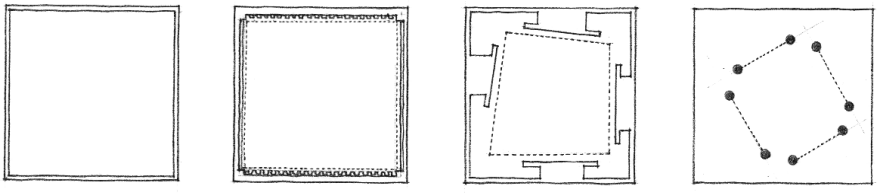


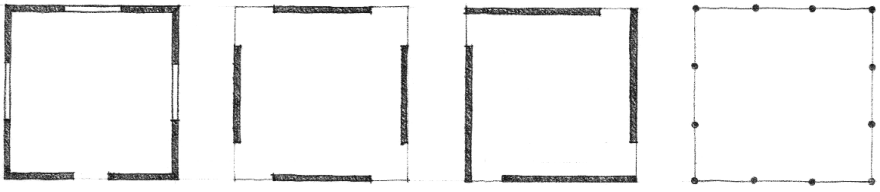


The basic patterns of linear and planar elements that define discrete volumes of space, and the varieties of openings that serve to connect these spatial volumes to one another and their context are presented on pages 194–195. The qualities of an architectural space, however, are much richer than what the diagrams are able to portray. The spatial qualities of form, proportion, scale, texture, light, and sound ultimately depend on the properties of the enclosure of a space. Our perception of these qualities is often a response to the combined effects of the properties encountered and is conditioned by culture, prior experiences, and personal interest or inclination.

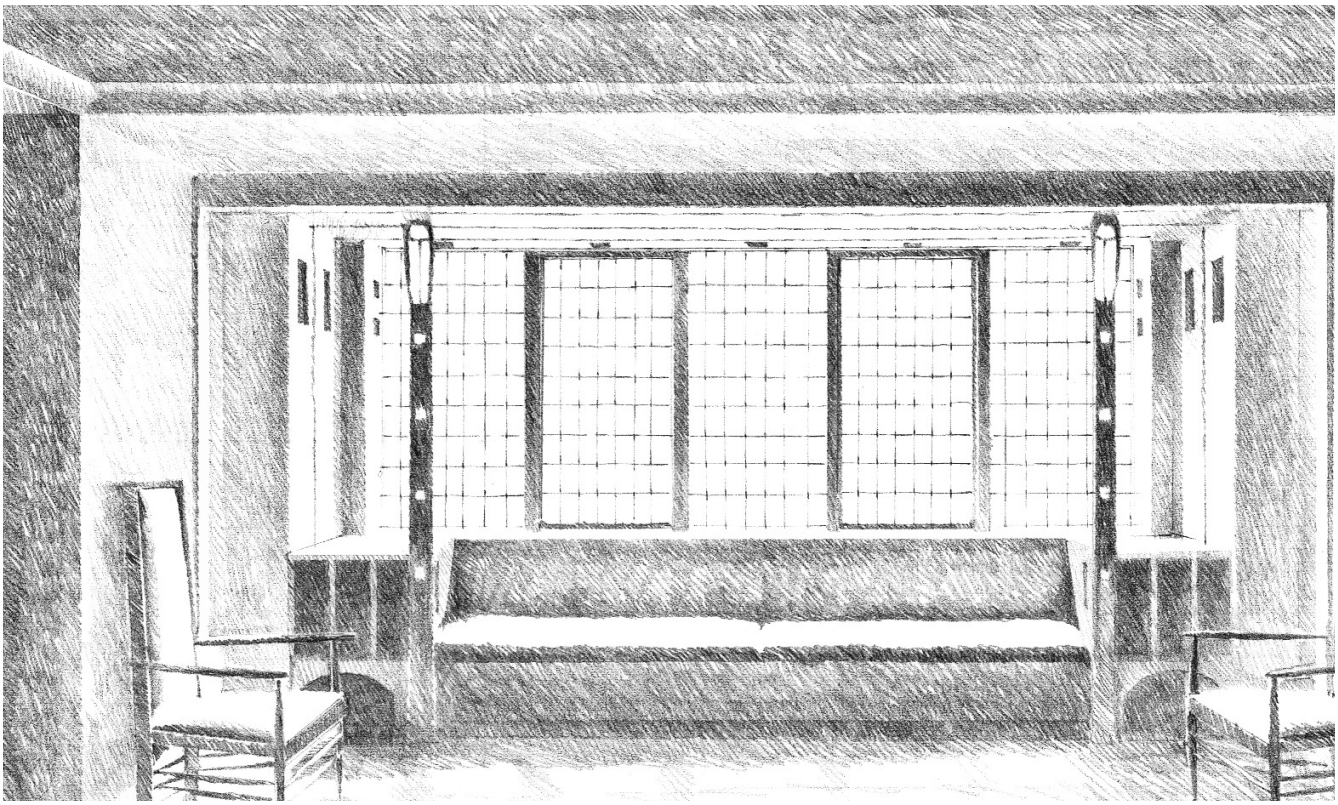








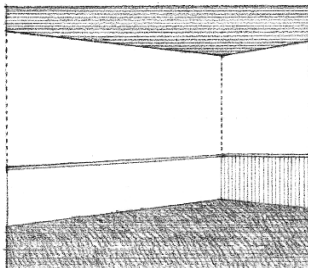
Properties of Enclosure	Qualities of Space
• Shape	• Form
• Surface • Edges	• Color • Texture • Pattern • Sound
• Dimensions	• Proportion • Scale
• Configuration	• Definition
• Openings	• Degree of enclosure • View or outlook • Light

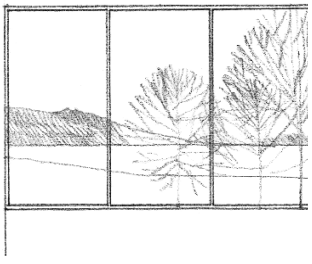


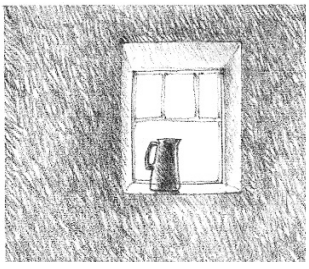
Bay Window of the Living Room, **Hill House**, Helensburgh, Scotland, 1902–1903, Charles Rennie Mackintosh

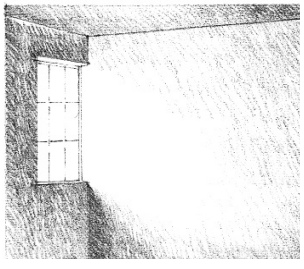
Chapter 2 discusses the impact of shape, surface, and edges on our perception of form. Chapter 6 presents the issues of dimensions, proportion, and scale. While the first part of this chapter outlines how basic configurations of linear and planar elements define volumes of space, this concluding section describes how the size, shape, and location of openings or voids within the enclosing forms of a space influence the following qualities of a room:

- **Degree of enclosure** . . . the form of the space
- **View or outlook** . . . . . the focus of the space
- **Light** . . . . . the illumination of its surfaces and forms



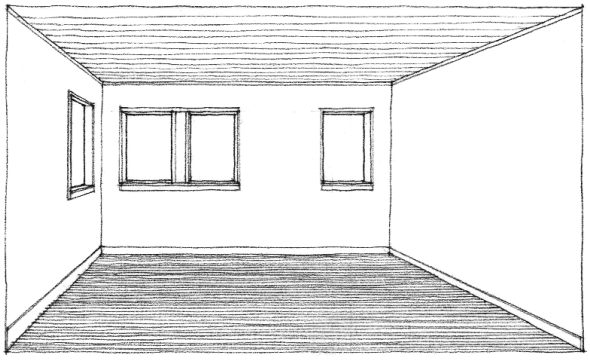


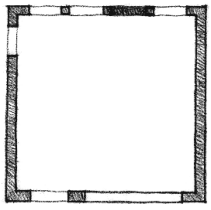


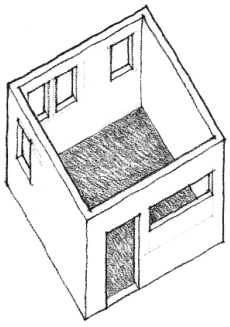


DEGREE OF ENCLOSURE

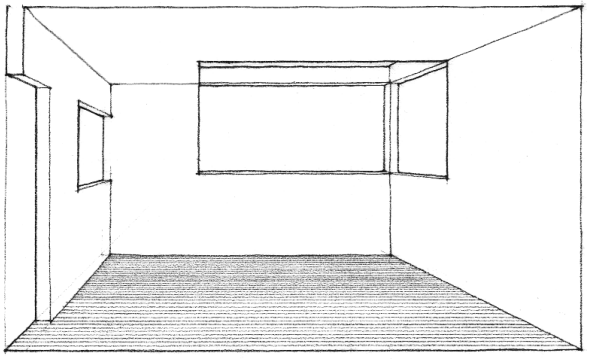
The degree of enclosure of a space, as determined by the configuration of its defining elements and the pattern of its openings, has a significant impact on our perception of its form and orientation. From within a space, we see only the surface of a wall. It is this thin layer of material that forms the vertical boundary of the space. The actual thickness of a wall plane can be revealed only along the edges of door and window openings.

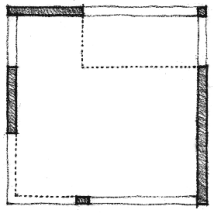


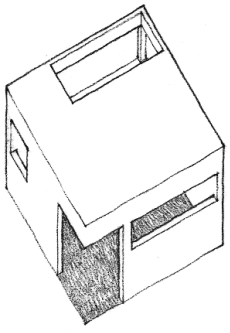




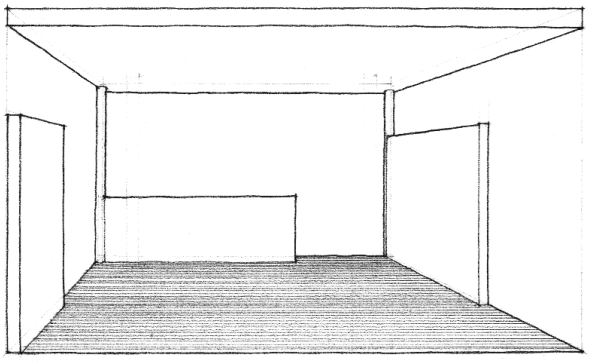
Openings lying wholly within the enclosing planes of a space do not weaken the edge definition nor the sense of closure of the space. The form of the space remains intact and perceptible.

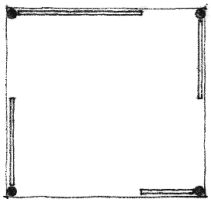


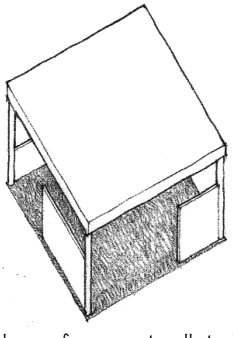




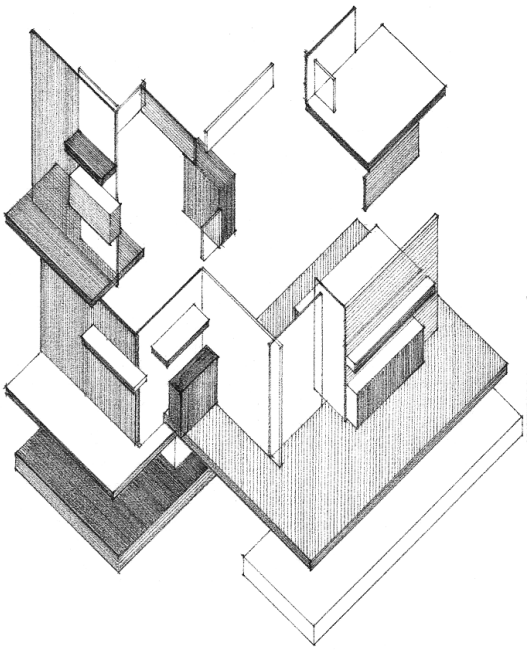
Openings located along the edges of the enclosing planes of a space visually weaken the corner boundaries of the volume. While these openings erode the overall form of a space, they also promote its visual continuity and interaction with adjacent spaces.



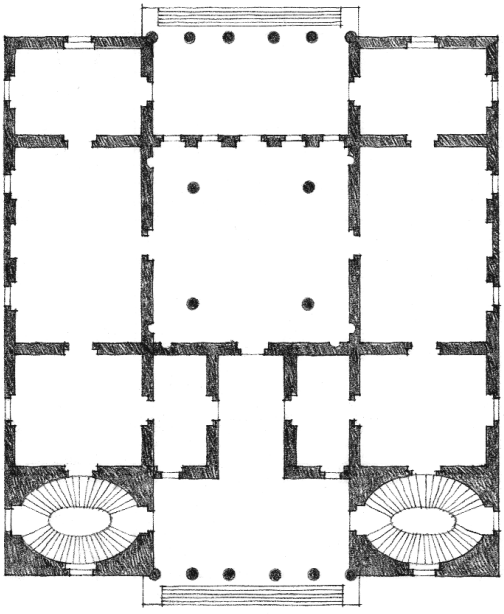




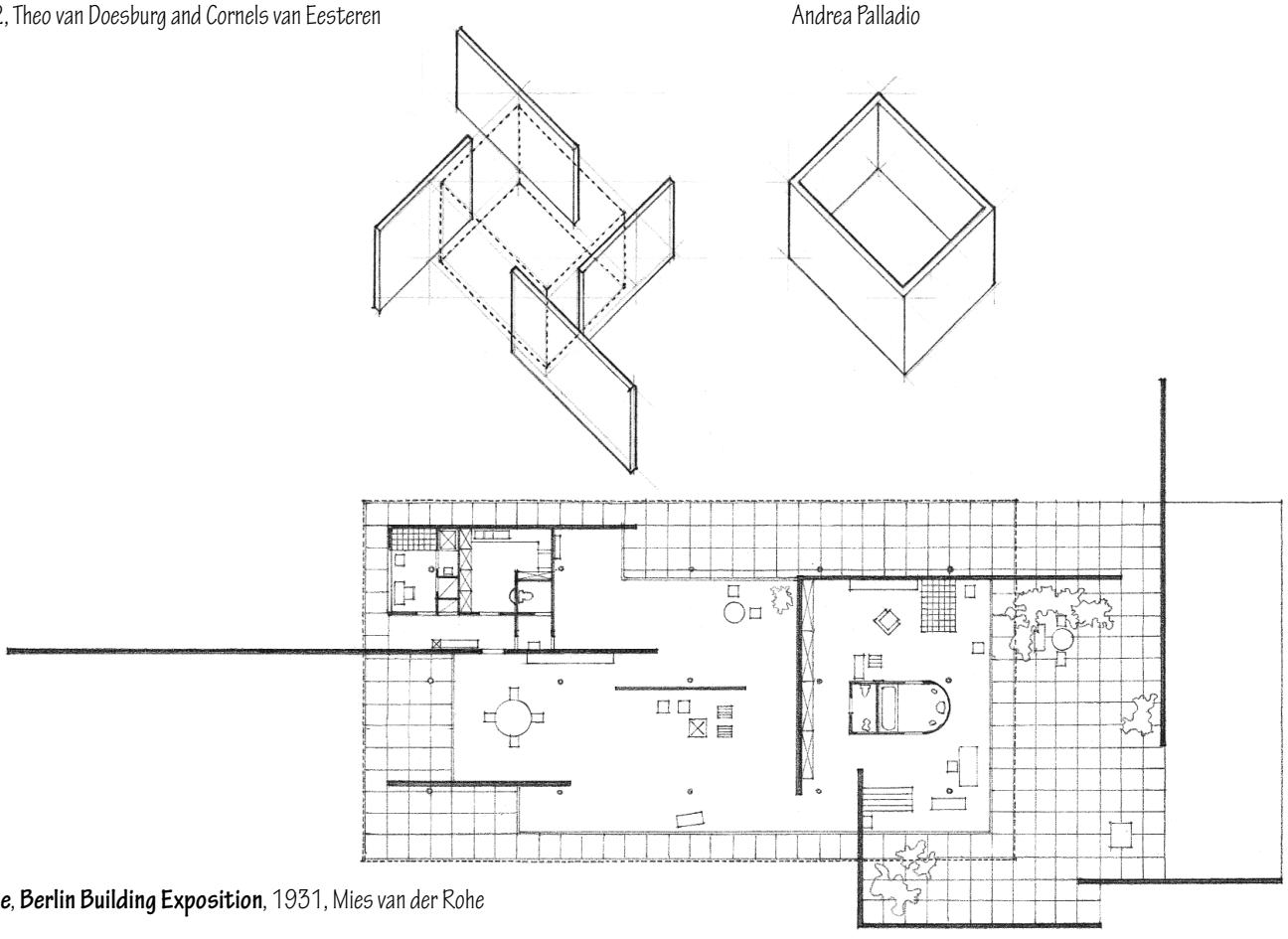
Openings between the enclosing planes of a space visually isolate the planes and articulate their individuality. As these openings increase in number and size, the space loses its sense of enclosure, becomes more diffuse, and begins to merge with adjacent spaces. The visual emphasis is on the enclosing planes rather than the volume of space defined by the planes.



Color Construction (Project for a Private House), 1922, Theo van Doesburg and Cornels van Eesteren



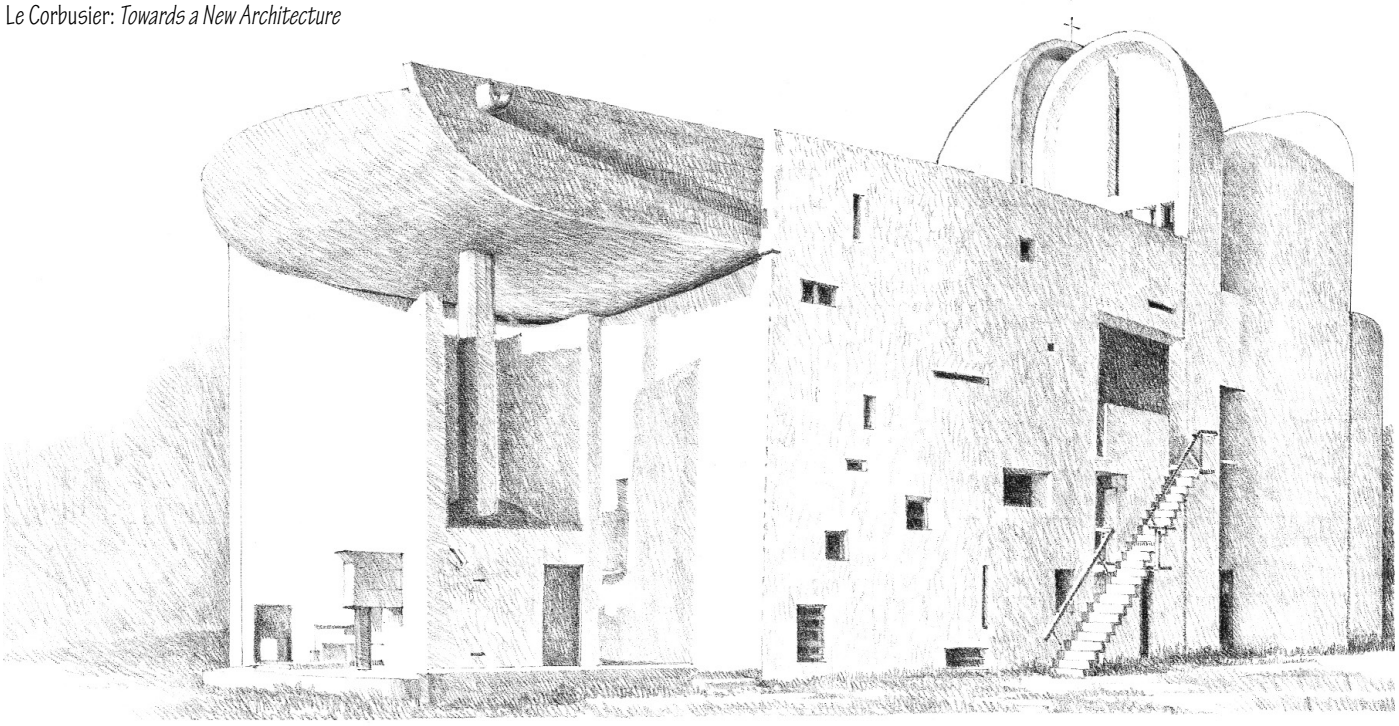
Palazzo Garzadore (Project), Vincenza, Italy, 1570, Andrea Palladio



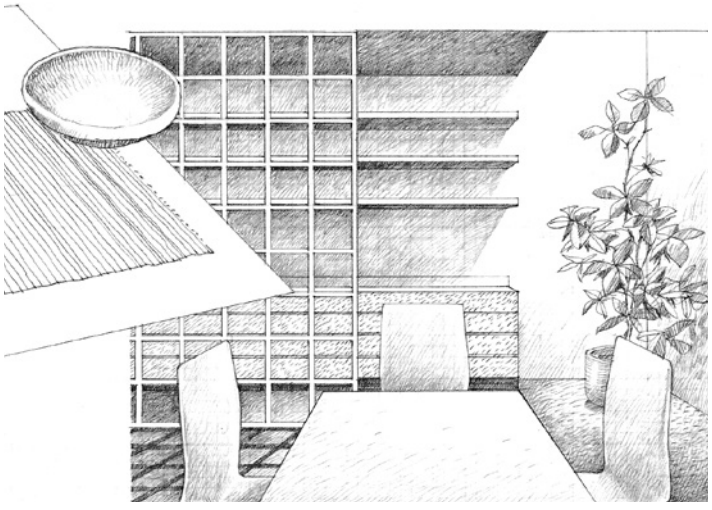
House, Berlin Building Exposition, 1931, Mies van der Rohe

LIGHT

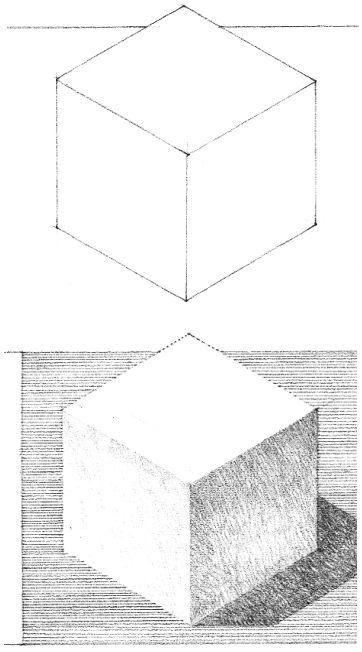
"Architecture is the masterly, correct and magnificent play of masses brought together in light. Our eyes are made to see forms in light; light and shade reveal these forms . . ."
Le Corbusier: *Towards a New Architecture*

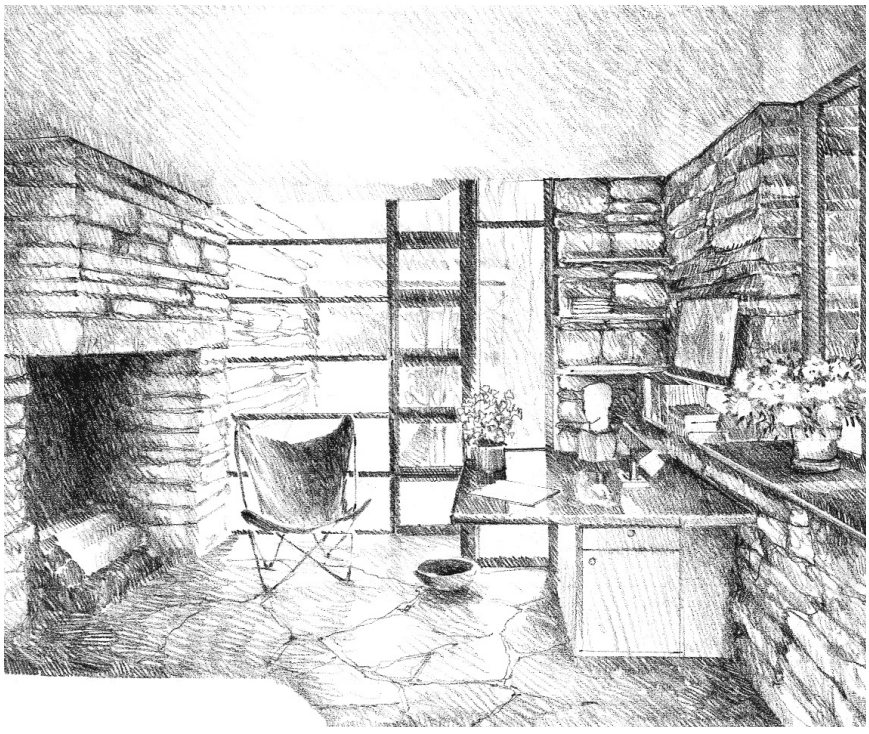


Notre Dame Du Haut, Ronchamp, France, 1950–1955, Le Corbusier



The sun is the rich source of natural light for the illumination of forms and spaces in architecture. While the sun's radiation is intense, the quality of its light, manifested in the form of direct sunlight or diffuse daylight, varies with the time of day, from season to season, and from place to place. As the luminous energy of the sun is dispersed by clouds, haze, and precipitation, it transmits the changing colors of the sky and the weather to the forms and surfaces it illuminates.

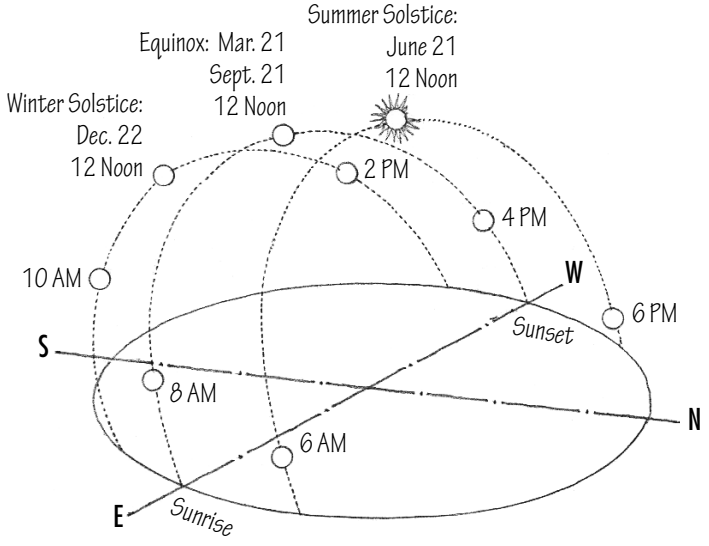




Fallingwater (Kaufmann House), near Ohiopyle, Pennsylvania ,1936–1937, Frank Lloyd Wright

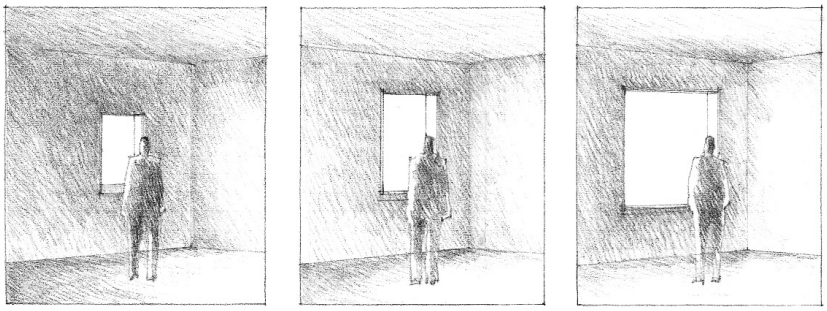
Penetrating a space through windows in a wall plane, or through skylights in the overhead roof plane, the radiant energy of the sun falls upon the surfaces within the room, enlivens their colors, and reveals their textures. With the shifting patterns of light, shade, and shadows that it creates, the sun animates the space of the room, and articulates the forms within it. By its intensity and dispersion within the room, the luminous energy of the sun can clarify the form of the space or distort it. The color and brilliance of sunlight can create a festive atmosphere within the room or a more diffuse daylight can instill within it a somber mood.

Since the intensity and direction of the light the sun radiates is fairly predictable, its visual impact on the surfaces, forms, and space of a room can be predicated on the size, location, and orientation of windows and skylights within the enclosure.

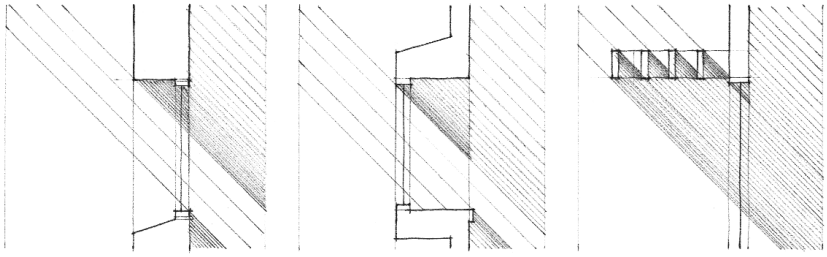


Sun-Path Diagram for the Northern Hemisphere

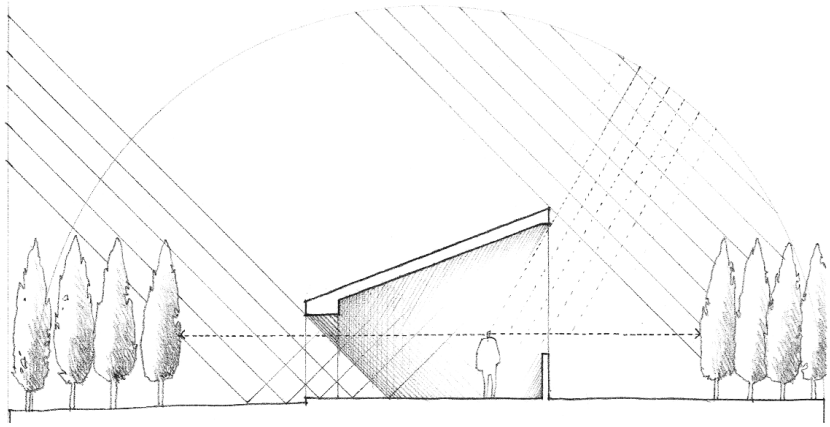
LIGHT



The size of a window or skylight controls the amount of daylight a room receives. The size of an opening in a wall or roof plane, however, is also regulated by factors other than light, such as the materials and construction of the wall or roof plane; code requirements for ventilation; the desire for views and visual privacy; the appropriate degree of enclosure for the space; and the effect of openings on the exterior form of a building. The location and orientation of a window or skylight, therefore, can be more important than its size in determining the quality of daylight a room receives.

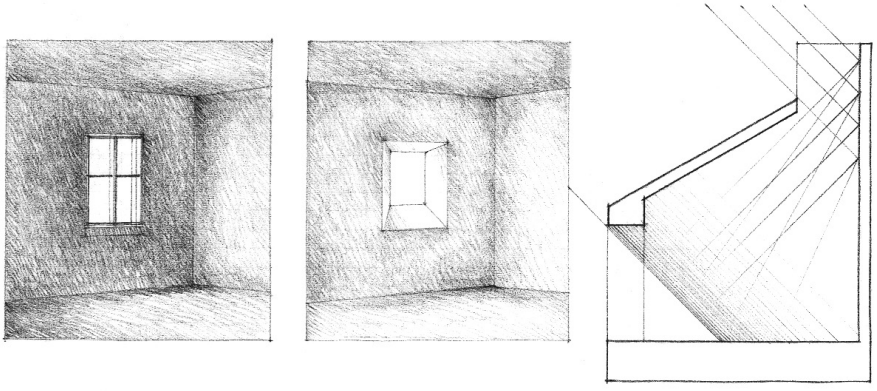


An opening can be oriented to receive direct sunlight during certain portions of the day. Direct sunlight provides a high degree of illumination that is especially intense during midday hours. It creates sharp patterns of light and dark on the surfaces of a room and crisply articulates the forms within the space. Possible detrimental effects of direct sunlight, such as glare and excessive heat gain, can be controlled by shading devices built into the form of the opening or provided by the foliage of nearby trees or adjacent structures.

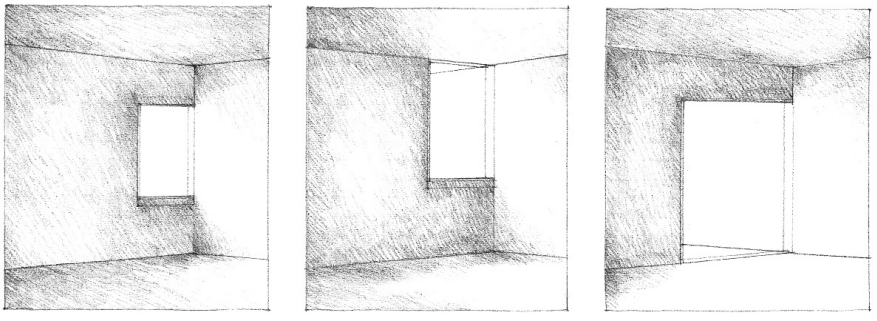


An opening can also be oriented away from direct sunlight and receive instead the diffuse, ambient light from the sky vault overhead. The sky vault is a beneficial source of daylight since it remains fairly constant, even on cloudy days, and can help to soften the harshness of direct sunlight and balance the light level within a space.

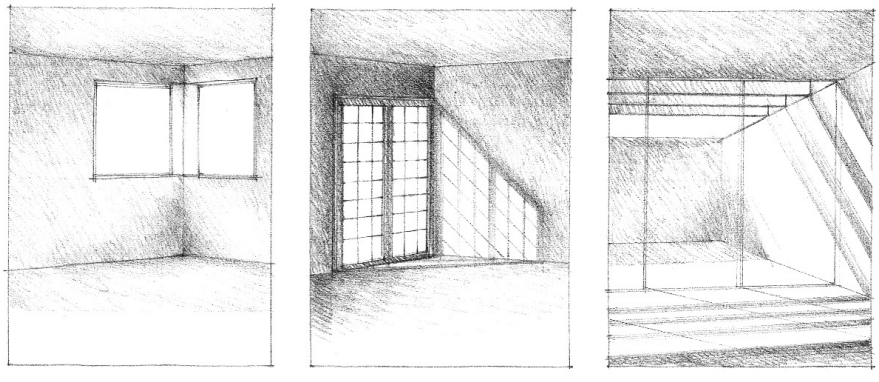
The location of an opening affects the manner in which natural light enters a room and illuminates its forms and surfaces. When located entirely within a wall plane, an opening can appear as a bright spot of light on a darker surface. This condition can induce glare if an excessive degree of contrast exists between the brightness of the opening and the darker surface surrounding it. The uncomfortable or debilitating glare caused by excessive brightness ratios between adjacent surfaces or areas in a room can be ameliorated by allowing daylight to enter the space from at least two directions.



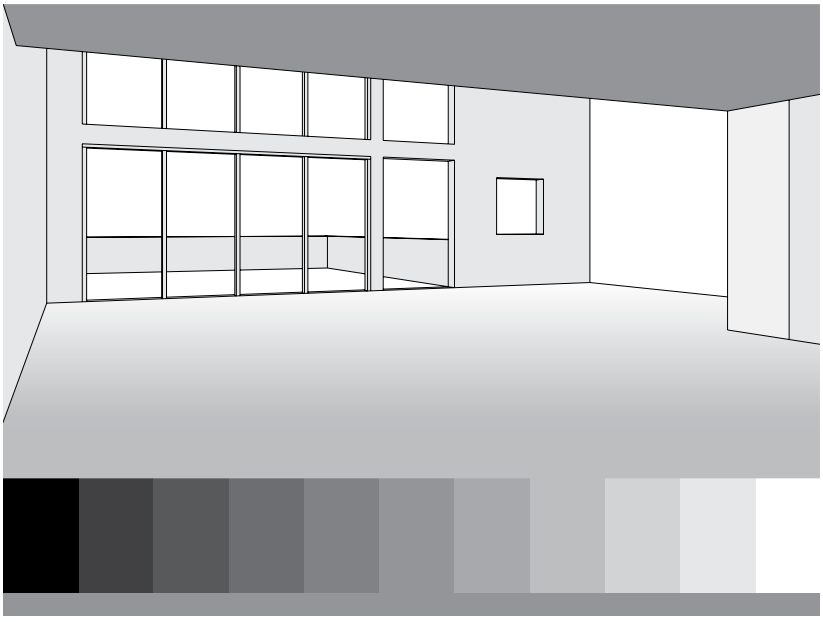
When an opening is located along the edge of a wall or at the corner of a room, the daylight entering through it will wash the surface of the wall adjacent and perpendicular to the plane of the opening. This illuminated surface itself becomes a source of light and enhances the light level within the space.



Additional factors influence the quality of light within a room. The shape and articulation of an opening is reflected in the shadow pattern cast by sunlight on the forms and surfaces of the room. The color and texture of these forms and surfaces, in turn, affect their reflectivity and the ambient light level within the space.

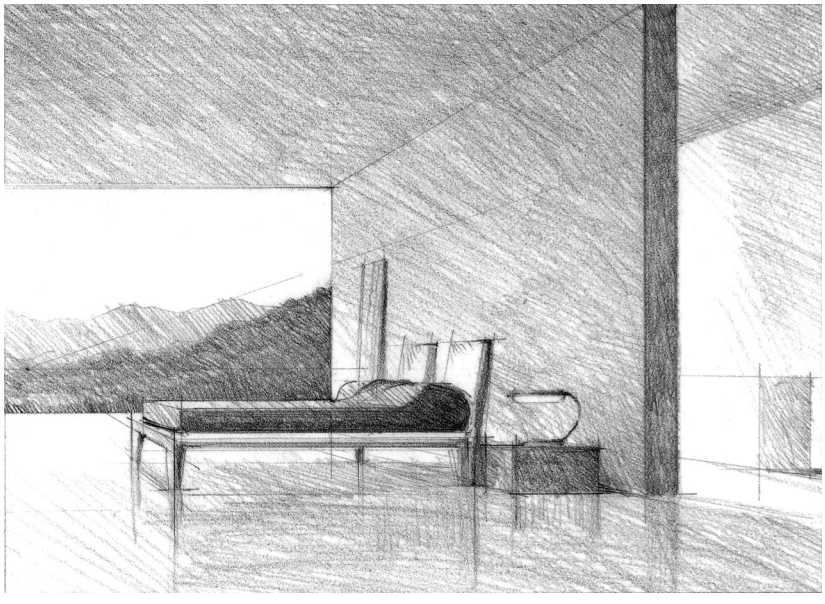


LIGHT



Daylighting provided by sidelighting and or by toplighting can offer the potential for significant energy savings. Optimizing glazing for daylighting is different from designing windows for views. The best daylighting approach is evenly spaced toplighting on the flat roof of a building, casting light evenly over a space. This of course is limited to single-story buildings, to the top floor of multistory buildings, or to those floors that can be readily reached through the use of light tubes. For sidelighting, windows are ideally located high on a wall, close to the ceiling, to cast light as deeply as possible into a space without introducing glare.

When used on an enclosing plane of a space, light values, cool hues, and grayed colors appear to recede and increase apparent distance. They can therefore be used to enhance the spaciousness of a room and increase its apparent width, length, or ceiling height.

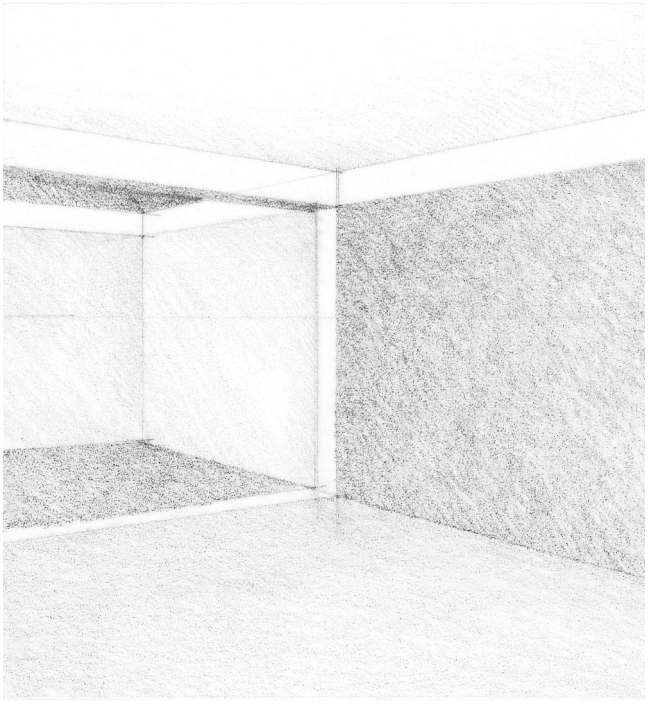


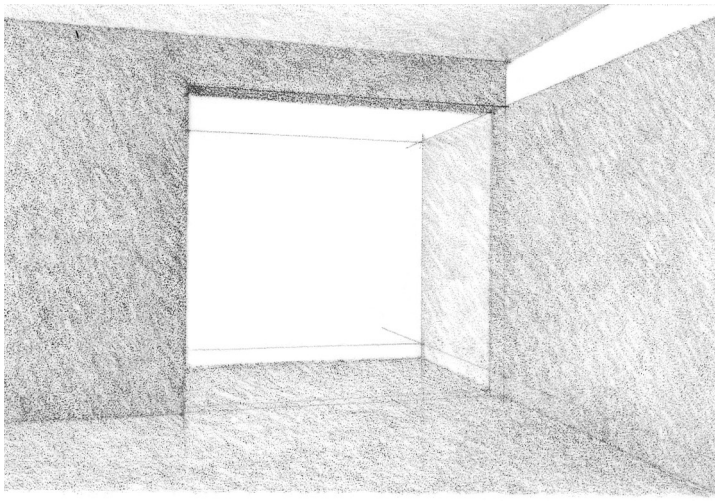
Of equal importance to chromatic distribution is tonal distribution, the pattern of lights and darks in a space. It is generally best to use varying amounts of light and dark values with a range of middle values to serve as transitional tones. Avoid using equal amounts of light and dark unless a fragmented effect is desired.

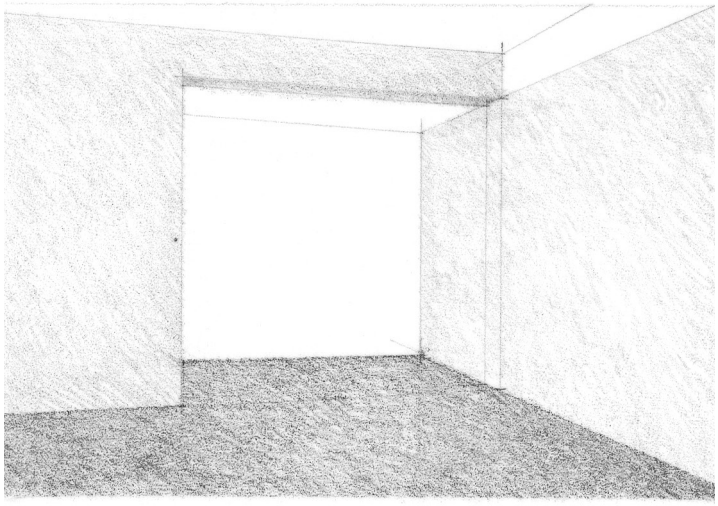
Typically, large areas of light value are offset by smaller areas of medium and dark values. This use of light values is particularly appropriate when the efficient use of available light is important. Dark color schemes can absorb much of the light within a space, resulting in a significant loss of illumination and an increase in energy use for lighting.

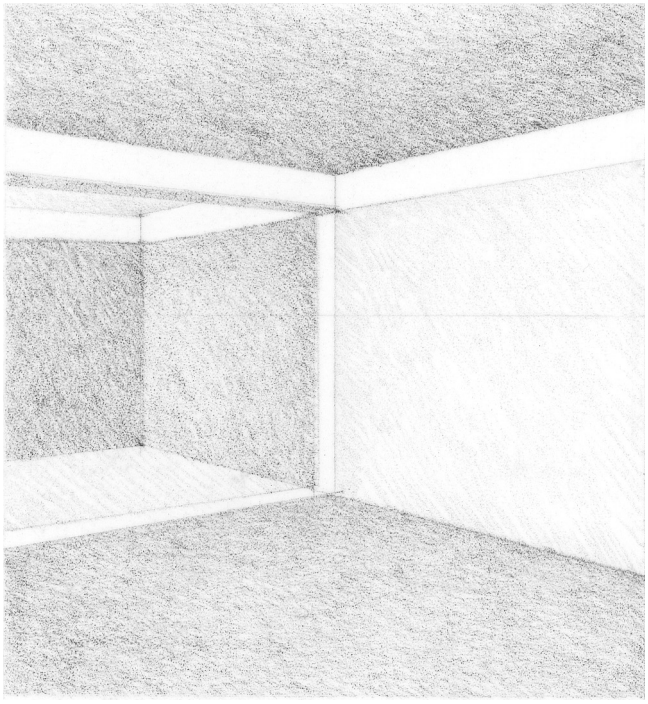
Another way of distributing values is to follow the pattern of nature. In this tonal sequence, the floor plane has the darkest value, surrounding walls are in the middle to light range, and the ceiling is fairly light.

Of course, the distribution of values and their degree of contrast will also depend on the size, shape, and scale of the space. Because light values tend to recede while dark values advance, their placement can modify our perception of these spatial dimensions.



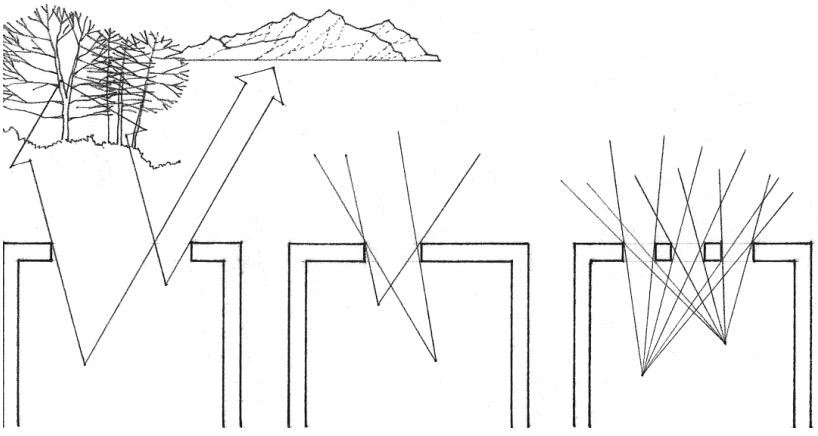






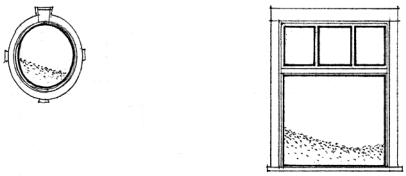
Tonal Values. These illustrations show the effect of tonal values on our perception of spatial boundaries.

VIEW

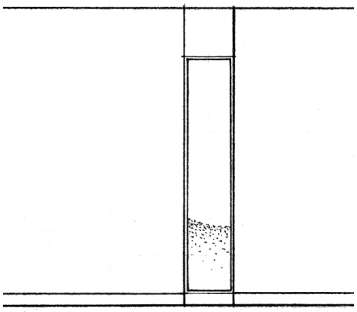


Another quality of space that must be considered in establishing openings in the enclosure of a room is its focus and orientation. While some rooms have an internal focus, such as a fireplace, others have an outward orientation given to them by a view to the outdoors or an adjacent space. Window and skylight openings provide this view and establish a visual relationship between a room and its surroundings. The size and location of these openings determine, of course, the nature of the outlook as well as the degree of visual privacy for an interior space.

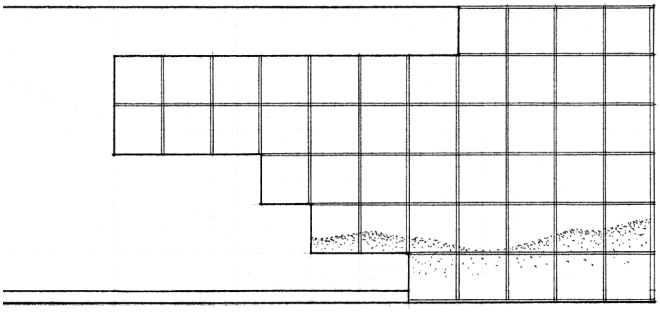
A small opening can reveal a close-up detail or frame a view so that we see it as a painting on a wall.



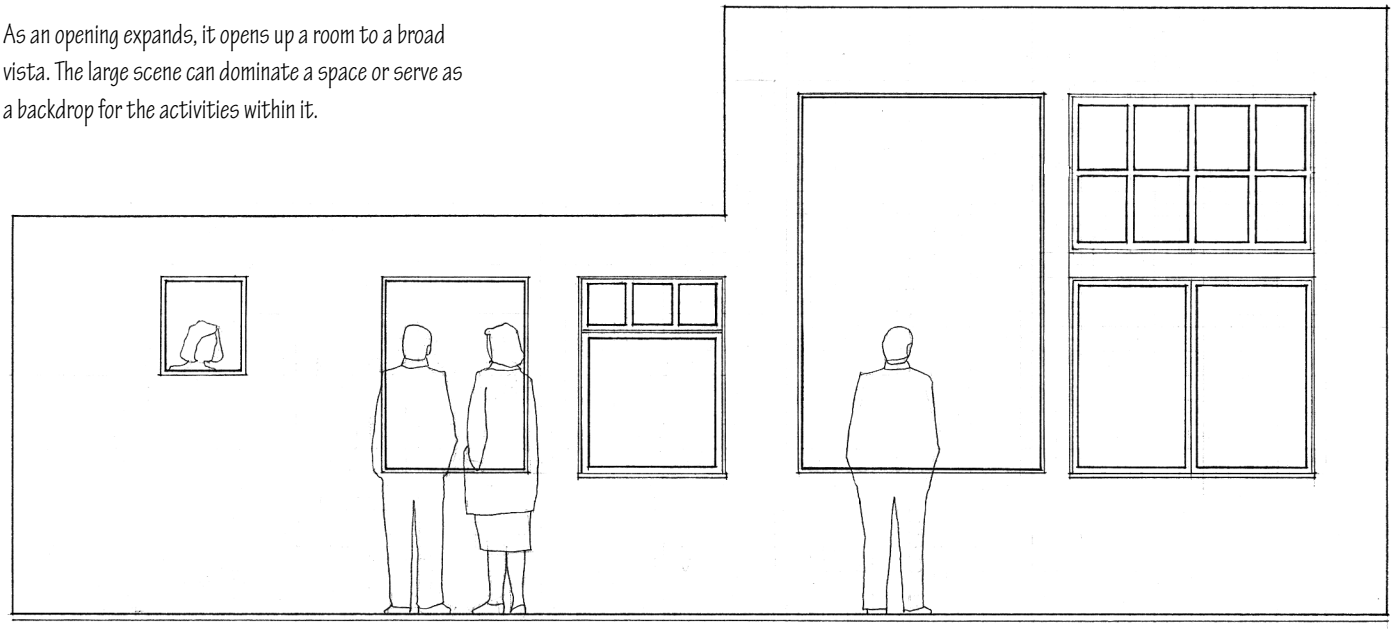
A long, narrow opening, whether vertical or horizontal, can not only separate two planes but also hint at what lies beyond.



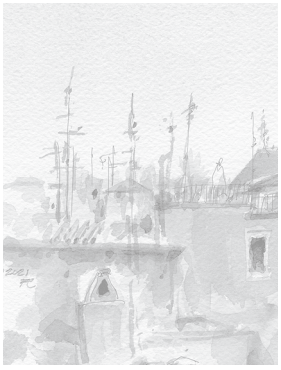
A group of windows can be sequenced to fragment a scene and encourage movement within a space.

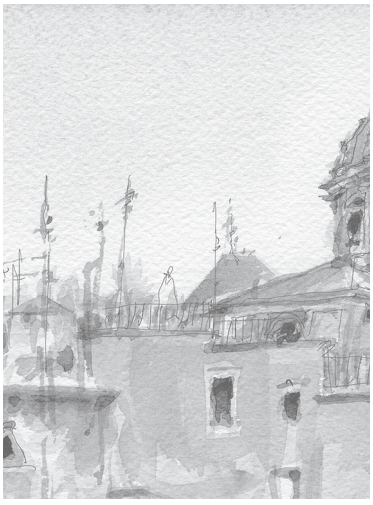


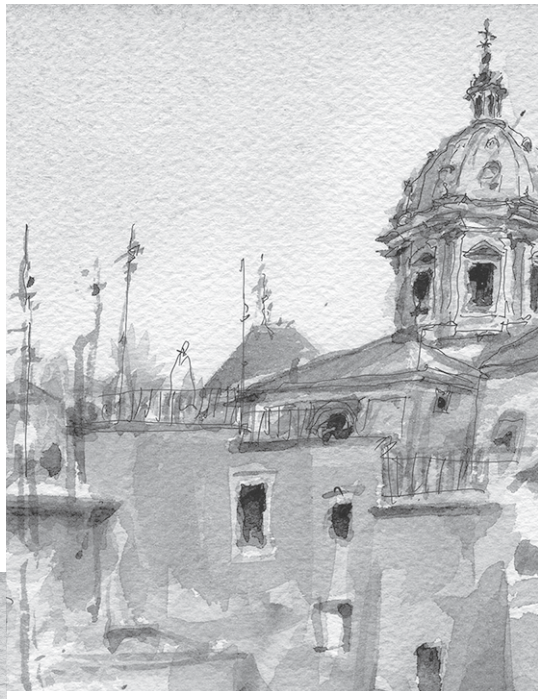
As an opening expands, it opens up a room to a broad vista. The large scene can dominate a space or serve as a backdrop for the activities within it.

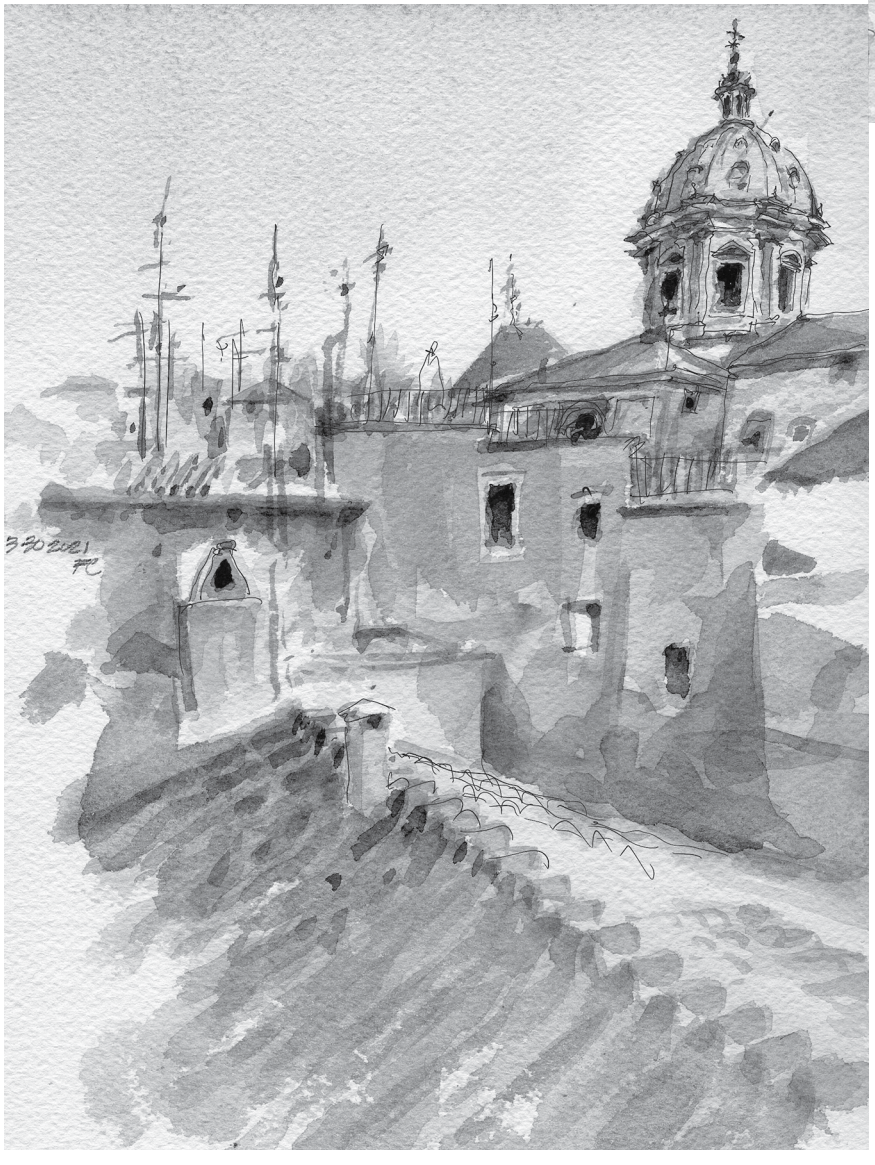


VIEW

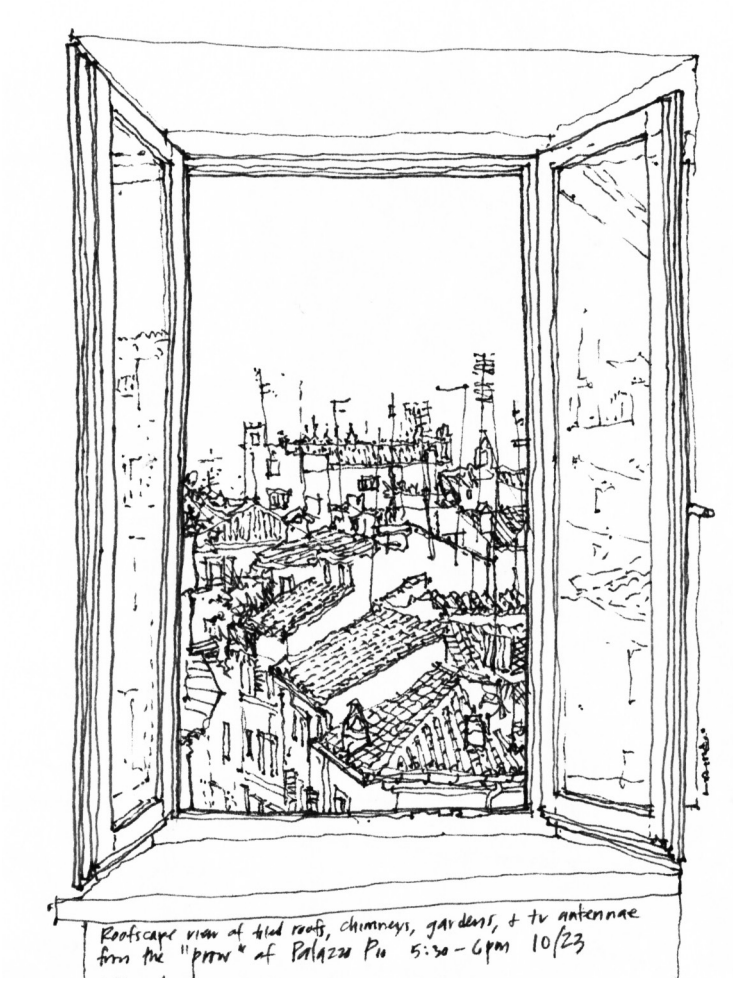




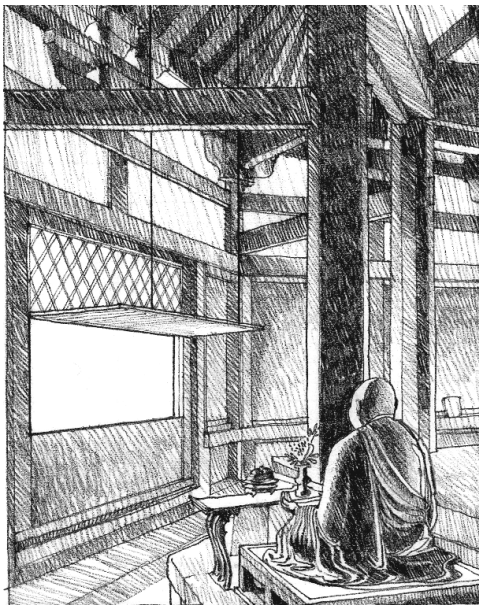




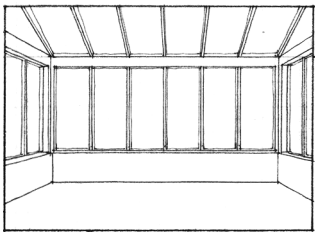
The framing of a view varies not only with the size and placement of a window but also with one's position within a space. From within a room, a view might be tightly framed. As one moves forward, however, the view will necessarily broaden and expand until the entire view is exposed from the window sill.

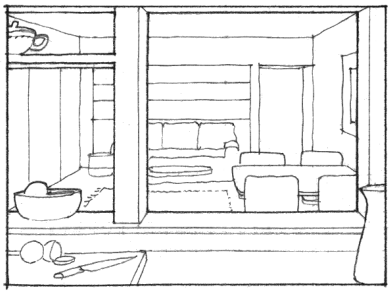


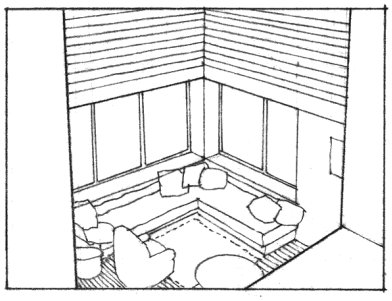
VIEW



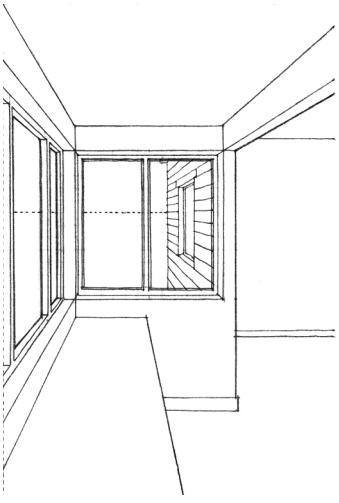
Outlook: Horyu-Ji Temple, Nara, Japan, A.D. 607.
A window can be located such that a specific view can be seen from only one position in a room.



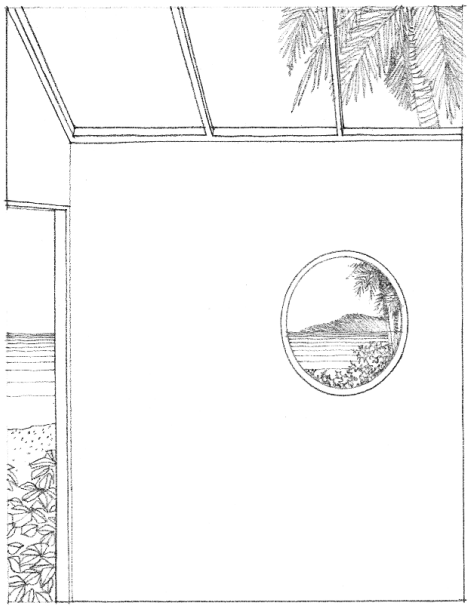


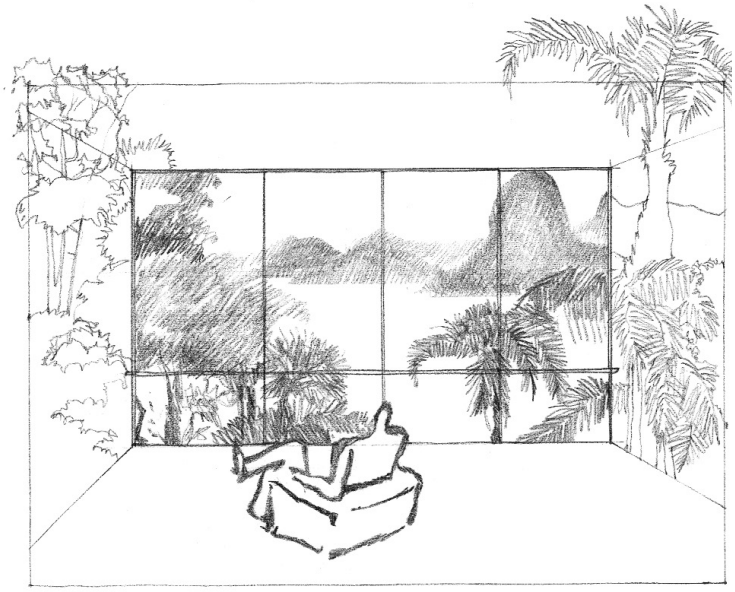


Interior openings offer views from one space to another. An opening can be oriented upward to offer a view of treetops and the sky.

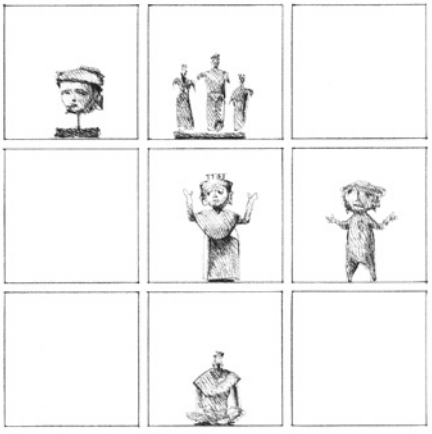


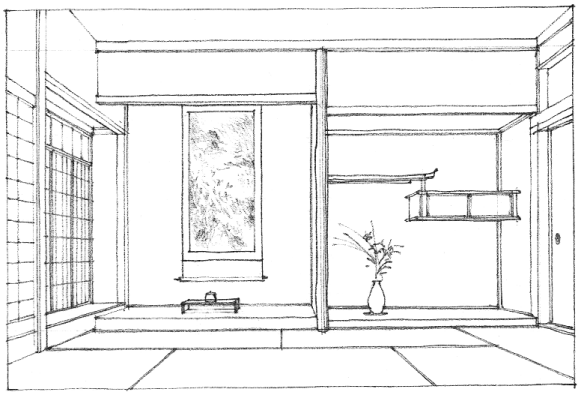
A bay window can project a person into a scene. If large enough, the projected space can become an alcove able to be occupied.





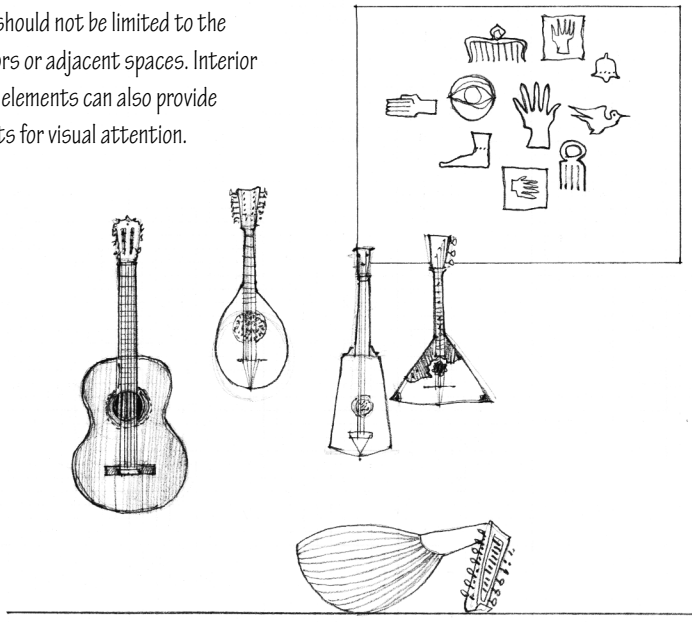
Vista, based on a sketch by Le Corbusier for the design of the Ministry of National Education and Public Health in Rio de Janeiro, 1936



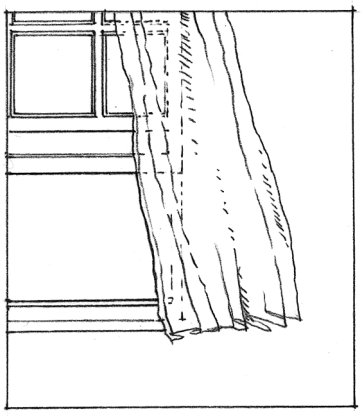


An Internal Focus: **Tokonoma**, the spiritual center of a traditional Japanese house

Views should not be limited to the outdoors or adjacent spaces. Interior design elements can also provide subjects for visual attention.



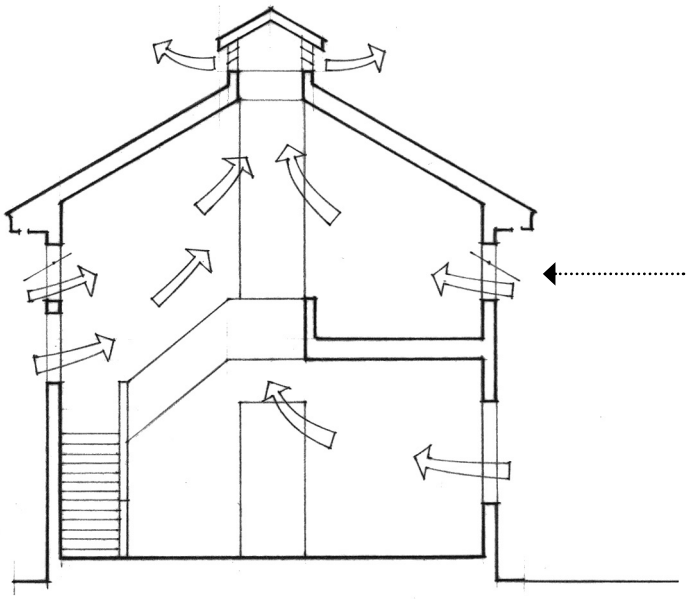
VENTILATION



In addition to daylighting and views, window openings can provide, if operable, the ventilation of habitable spaces required by building codes. Natural ventilation relies on the natural movement of air rather than mechanical means, and is an important component of sustainable design and encouraged by green building standards.

Natural ventilation consists of using natural forces to impel airflow though a space. Its three goals are to ensure improved indoor air quality and reduce energy consumption while maximizing the thermal comfort for the occupants using the space.

Wind speed, temperature, and direction are important site considerations in locating window openings in all climatic regions. During hot periods, wind-induced ventilation is desirable for cooling by evaporation or conduction. In cold weather, wind should be avoided or screened from windows to minimize the infiltration of cold air into a building. At all times, some degree of ventilation is desirable for good health and the removal of stale air and odors from interior spaces.



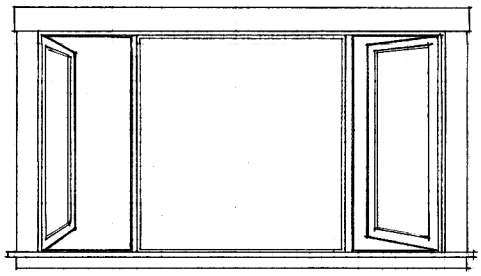
Two natural forces can be used to induce air flow through a building: wind and buoyancy, which lead, respectively, to two main natural ventilation strategies: cross ventilation and stack ventilation.

Stack ventilation relies on the temperature difference between the air inside the building and the outdoors to drive the air flow. Warmer air is lighter than colder air, and so when a region of warm air is exposed to an environment with cooler air, the warmer, lighter air will escape through higher openings and the cooler, heavier air will enter the building through lower openings. For buoyancy-driven ventilation, attention must be directed to the pathways by which ventilation air flows through the building.

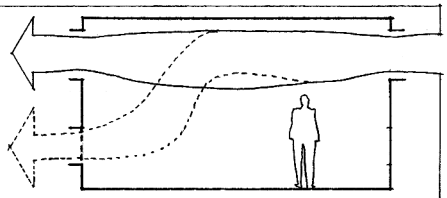
Cross ventilation is an important strategy for natural ventilation. It occurs when wind hits the windward side of a building, creating a positive pressure on that facade and a region of lower pressure on the opposite, leeward side. If windows are open in the building on both the windward and leeward sides, air will be drawn through the building because of the pressure difference between the openings. Airflow patterns induced by these forces are affected more by building geometry than air speed.

How well cross ventilation works depends on:

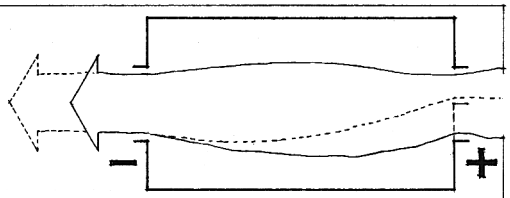
- Building location with respect to the prevailing winds.
- The sizing of windows and other openings.
- The interior layout of spaces and corridors.
- The location of furniture and other potential airflow obstructions.



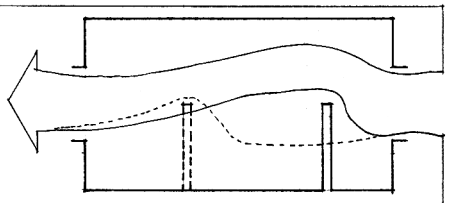
Natural ventilation requires the use of operable windows.



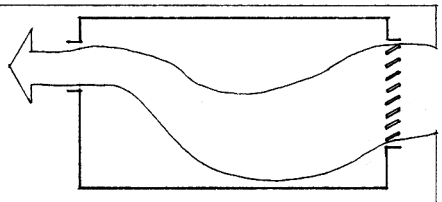
High inlets and outlets produce air movement above our body level. Lowering the outlets does not ameliorate this condition.



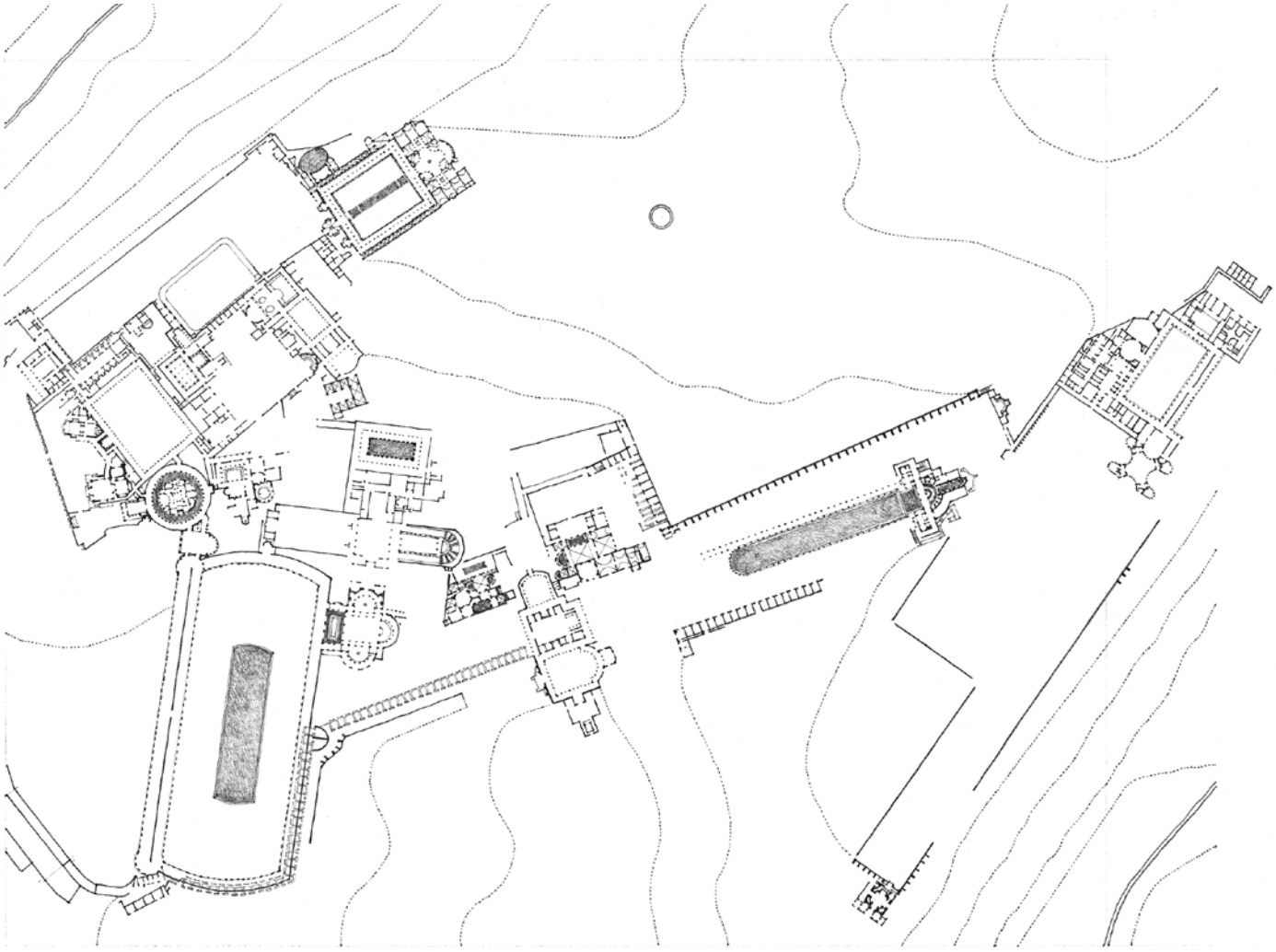
Air flows from higher to lower pressure zones. Air flow is accelerated when inlets are smaller than outlets.



Interior partitions and tall furnishings can adversely affect the pattern of air flow.



Louvers can help direct air flow.



Hadrian's Villa, Tivoli, Italy, A.D. 118–125

4

Organization

"... A good house is a single thing, as well as a collection of many, and to make it requires a conceptual leap from the individual components to a vision of the whole. The choices ... represent ways of assembling the parts.
... the basic parts of a house can be put together to make more than just basic parts: They can also make space, pattern, and outside domains. They dramatize the most elementary act which architecture has to perform. To make one plus one equal more than two, you must in doing any one thing you think important (making rooms, putting them together, or fitting them to the land) do something else that you think important as well (make spaces to live, establish a meaningful pattern inside, or claim other realms outside)."

Charles Moore, Gerald Allen, Donlyn Lyndon
The Place of Houses
1974

Architecture: Form, Space, & Order, Fifth Edition. Francis D. K. Ching.
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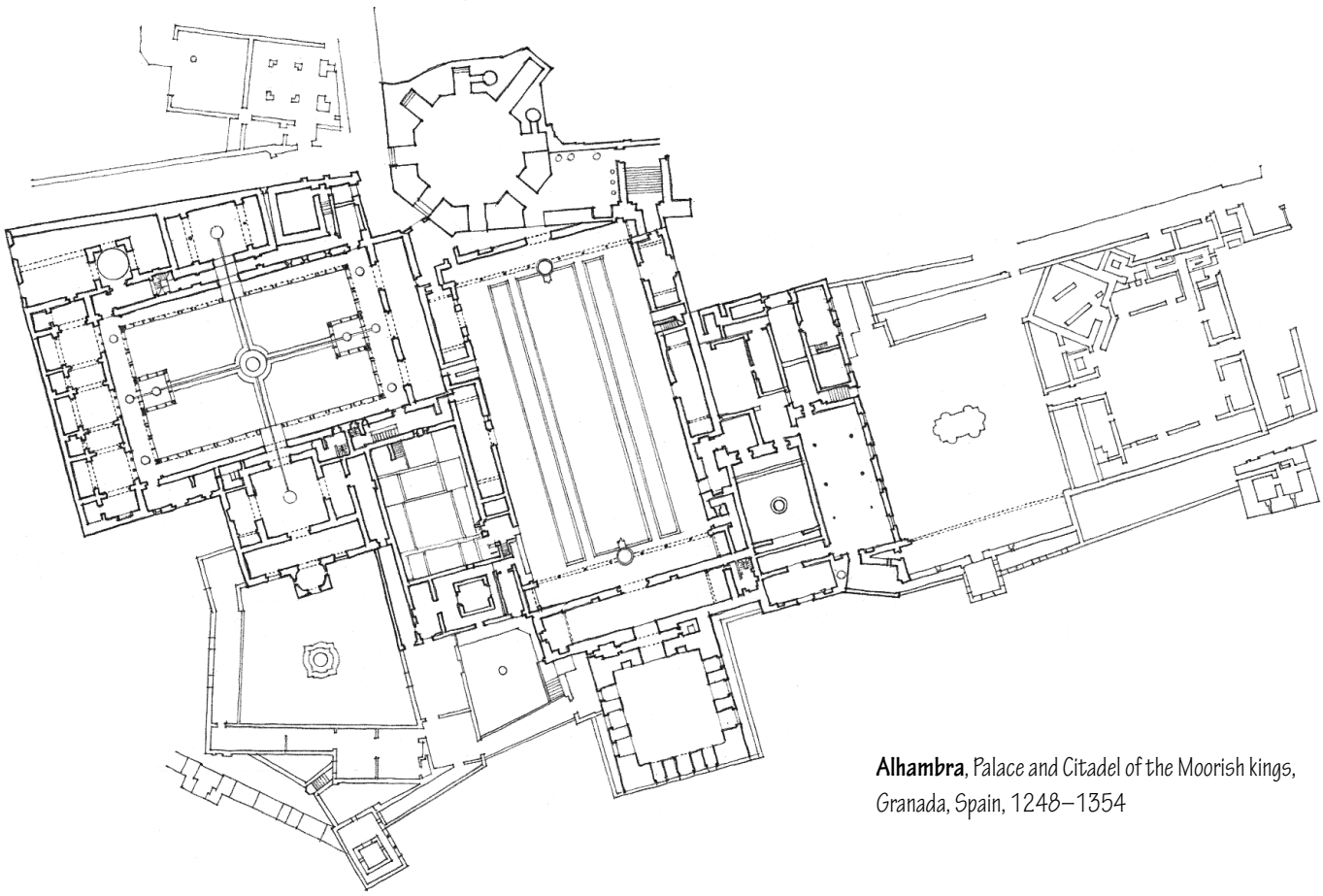
Companion Website: www.wiley.com/go/ching/architecturefso5e

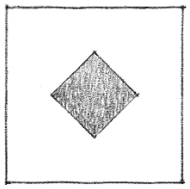
ORGANIZATION OF FORM & SPACE

The last chapter laid out how various configurations of form could be manipulated to define a solitary field or volume of space, and how their patterns of solids and voids affected the visual qualities of the defined space. Few buildings, however, consist of a solitary space. They are normally composed of a number of spaces that are related to one another by function, proximity, or a path of movement. This chapter lays out for study and discussion the basic ways the spaces of a building can be related to one another and organized into coherent patterns of form and space.



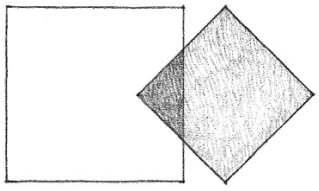
Alhambra, Palace and Citadel of the Moorish kings, Granada, Spain, 1248–1354

Two spaces may be related to each other in several fundamental ways.



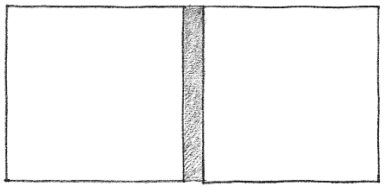
Space within a Space

A space may be contained within the volume of a larger space.



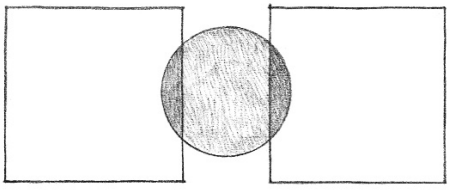
Interlocking Spaces

The field of a space may overlap the volume of another space.



Adjacent Spaces

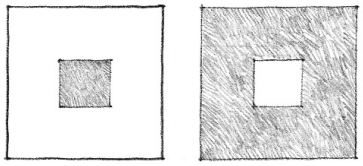
Two spaces may abut each other or share a common border.

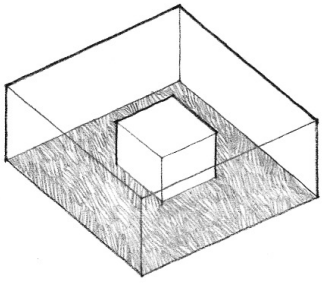


Spaces Linked by a Common Space

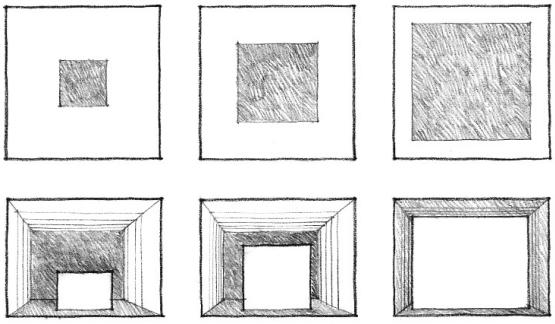
Two spaces may rely on an intermediary space for their relationship.

SPACE WITHIN A SPACE

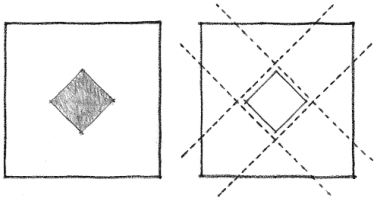


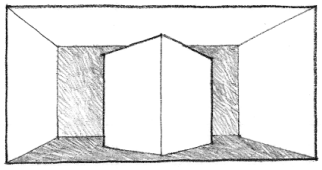


A large space can envelop and contain a smaller space within its volume. Visual and spatial continuity between the two spaces can be easily accommodated, but the smaller, contained space depends on the larger, enveloping space for its relationship to the exterior environment.

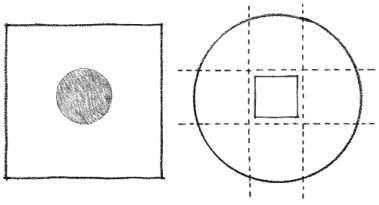


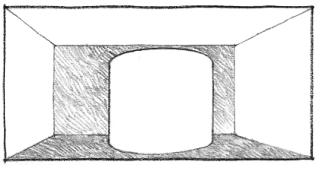
In this type of spatial relationship, the larger, enveloping space serves as a three-dimensional field for the smaller space contained within it. For this concept to be perceived, a clear differentiation in size is necessary between the two spaces. If the contained space were to increase in size, the larger space would begin to lose its impact as an enveloping form. If the contained space continued to grow, the residual space around it would become too compressed to serve as an enveloping space. It would become instead merely a thin layer or skin around the contained space. The original notion would be destroyed.





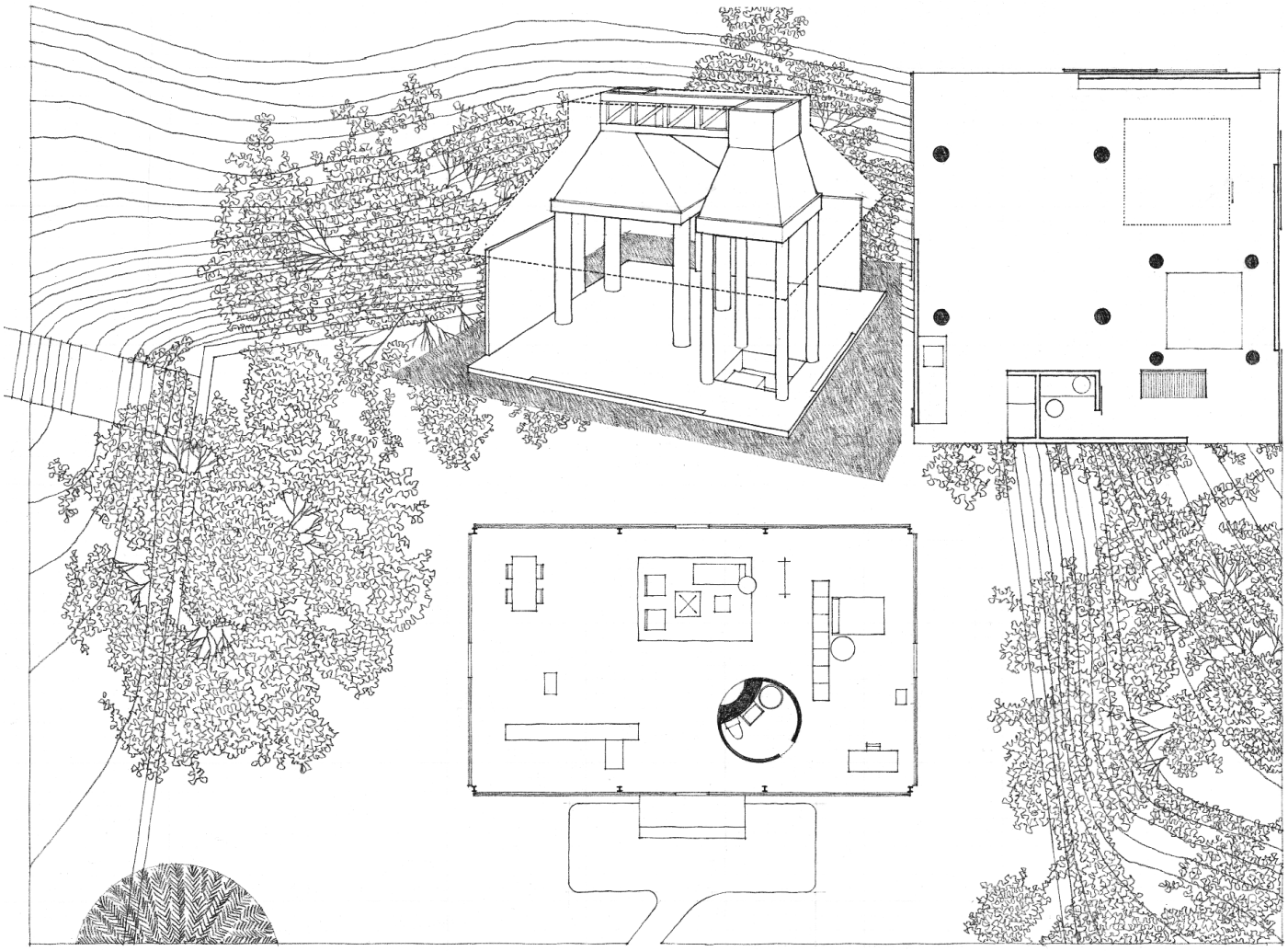
To endow itself with a higher attention-value, the contained space may share the form of the enveloping shape, but be oriented in a different manner. This would create a secondary grid and a set of dynamic, residual spaces within the larger space.





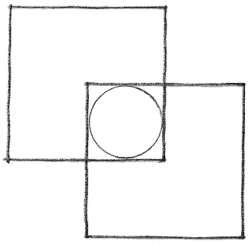
The contained space may also differ in form from the enveloping space in order to strengthen its image as a freestanding volume. This contrast in form may indicate a functional difference between the two spaces or the symbolic importance of the contained space.

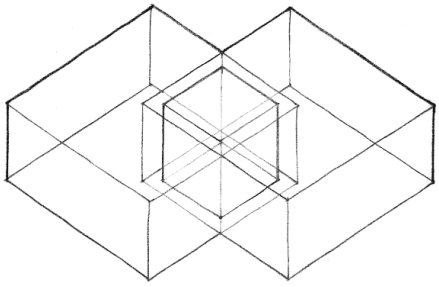
Moore House, Orinda, California, 1961, Charles Moore



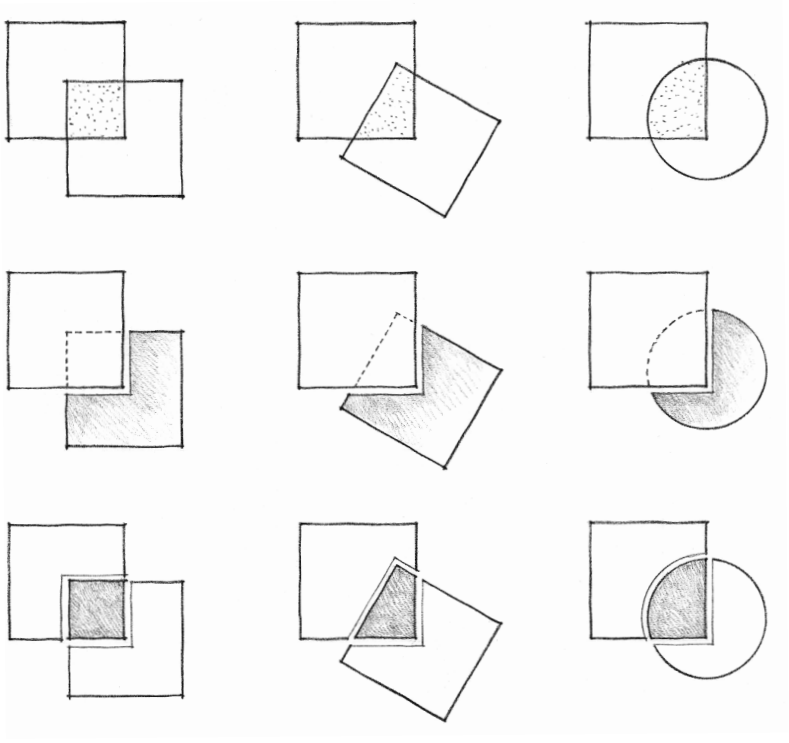
Glass House, New Canaan, Connecticut, 1949, Philip Johnson

INTERLOCKING SPACES





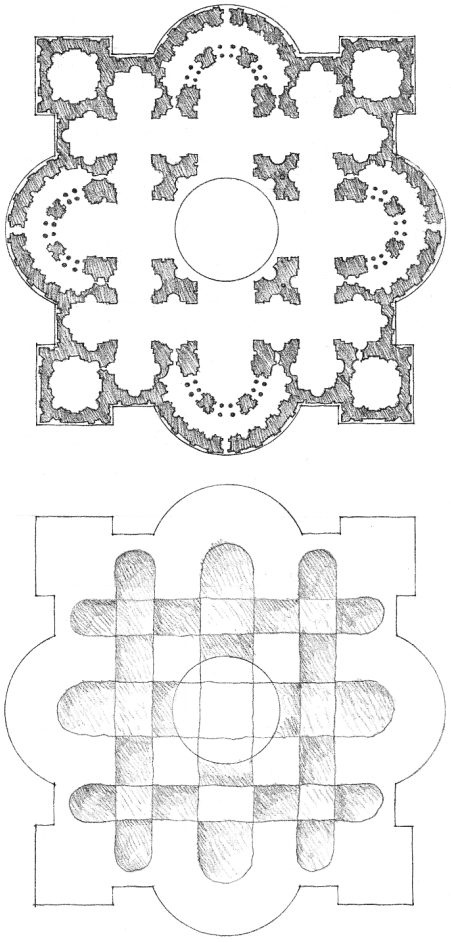
An interlocking spatial relationship results from the overlapping of two spatial fields and the emergence of a zone of shared space. When two spaces interlock their volumes in this manner, each retains its identity and definition as a space. But the resulting configuration of the two interlocking spaces is subject to a number of interpretations.



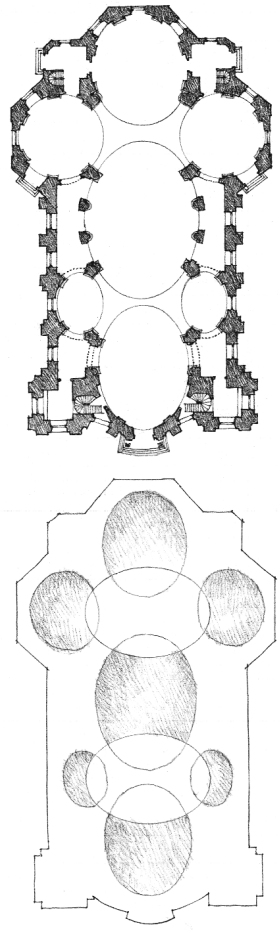
The interlocking portion of the two volumes can be shared equally by each space.

The interlocking portion can merge with one of the spaces and become an integral part of its volume.

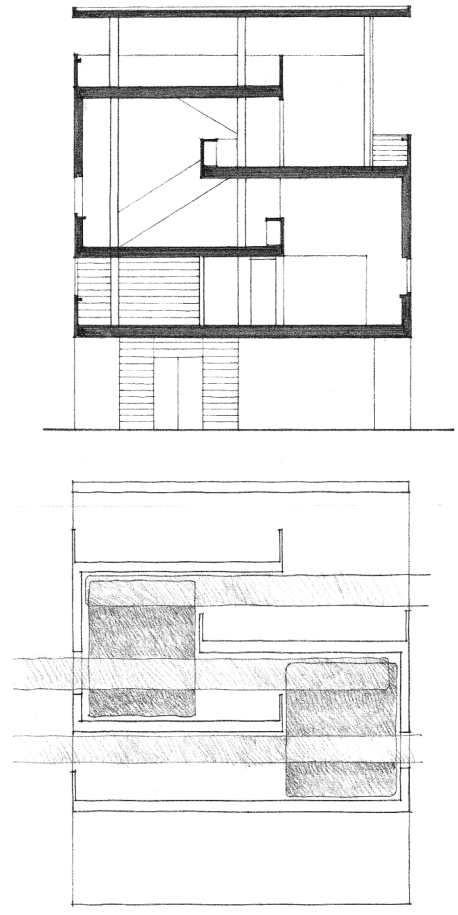
The interlocking portion can develop its own integrity as a space that serves to link the two original spaces.



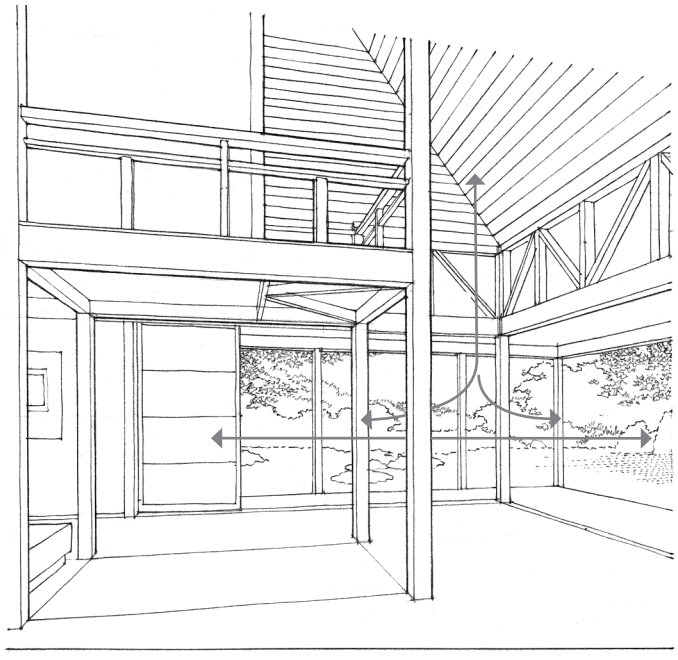
Plan for St. Peter (Second Version), Rome, 1506–1520, Donato Bramante & Baldassare Peruzzi



Pilgrimage Church, Vierzehnheiligen, Germany, 1744–1772, Balthasar Neumann

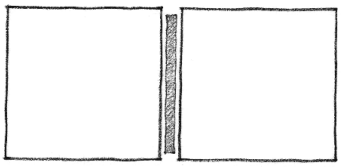


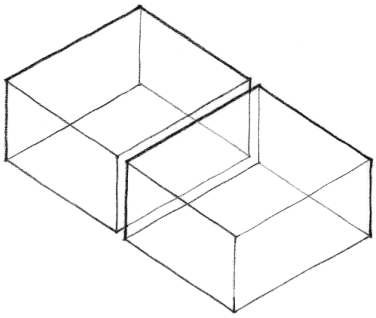
Villa at Carthage, Tunisia, 1928, Le Corbusier



The one-story space flows into the larger volume of which it is a part and to the outdoors.

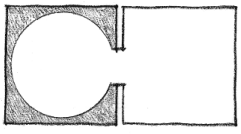
ADJACENT SPACES

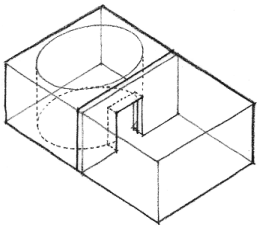


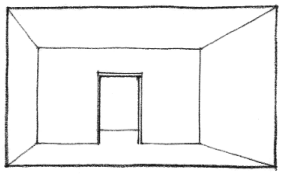


Adjacency is the most common type of spatial relationship. It allows each space to be clearly defined and to respond, each in its own way, to specific functional or symbolic requirements. The degree of visual and spatial continuity that occurs between two adjacent spaces depends on the nature of the plane that both separates and binds them together.

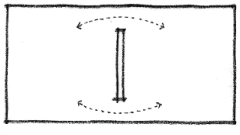
The separating plane may:

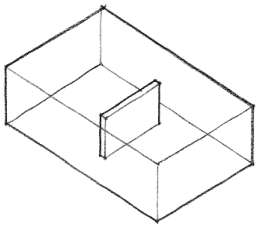


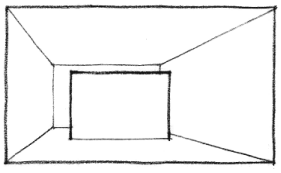




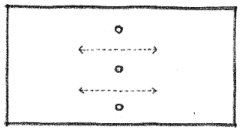
- Limit visual and physical access between two adjacent spaces, reinforce the individuality of each space, and accommodate their differences.

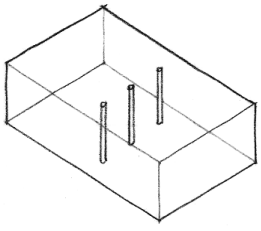


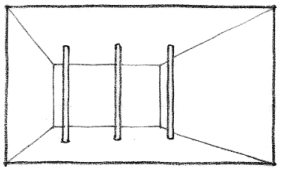




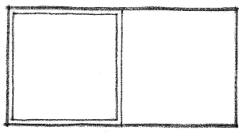
- Appear as a freestanding plane in a single volume of space.

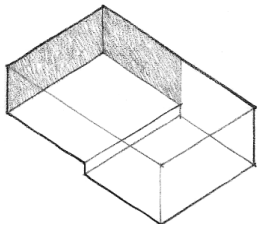


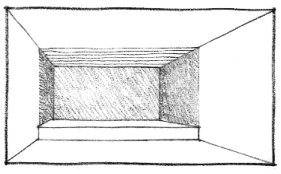




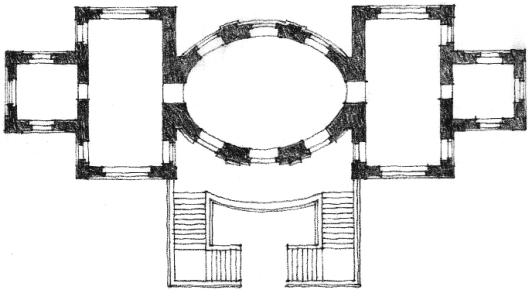
- Be defined with a row of columns that allows a high degree of visual and spatial continuity between the two spaces.



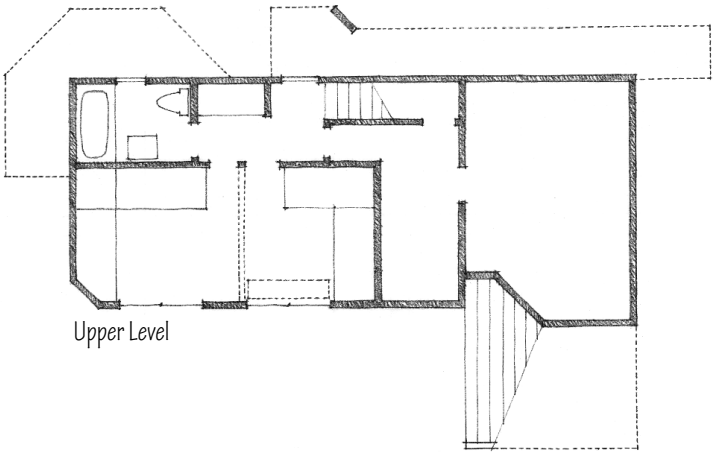




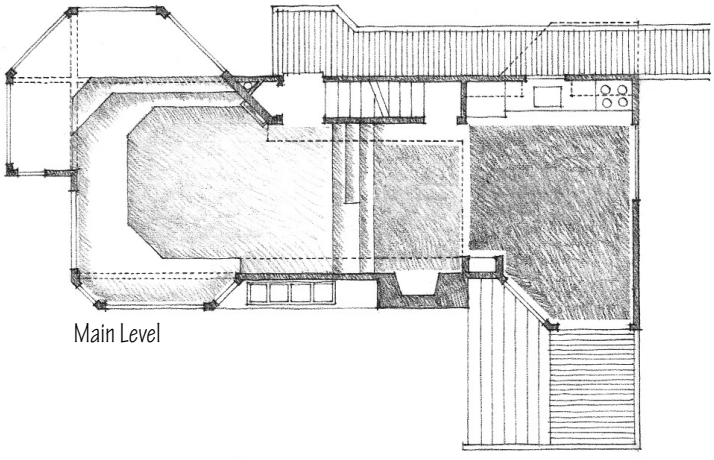
- Be merely implied with a change in level or a contrast in surface material or texture between the two spaces. This and the preceding two cases can also be read as single volumes of space which are divided into two related zones.



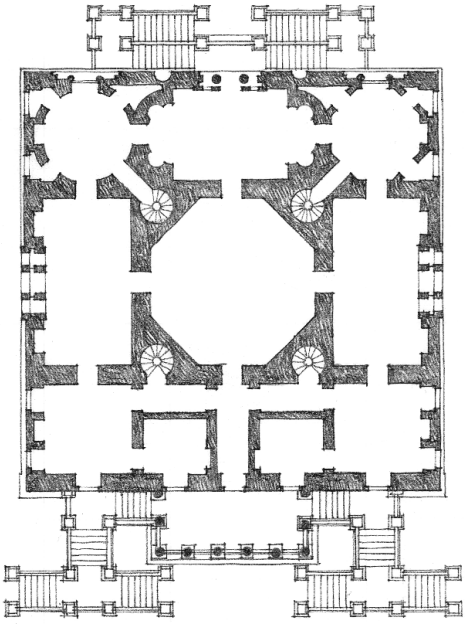
Pavilion Design, 17th century, Fischer von Erlach



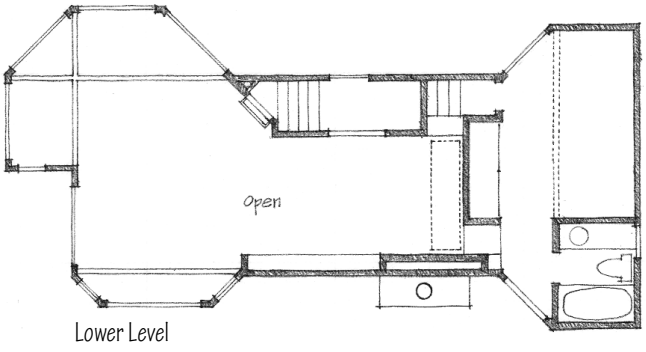
The spaces in these two buildings are individualistic in size, shape, and form. The walls that enclose them adapt their forms to accommodate the differences between adjacent spaces.



Three spaces—the living, fireplace, and dining areas—are defined by changes in floor level, ceiling height, and quality of light and view, rather than by wall planes.

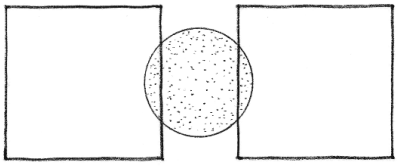


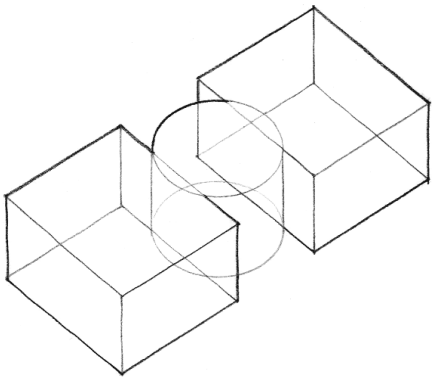
Chiswick House, London, England, 1729, Lord Burlington & William Kent



Lawrence House, Sea Ranch, California, 1966, Moore-Turnbull/MLTW

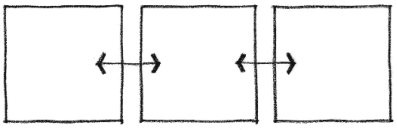
SPACES LINKED BY A COMMON SPACE



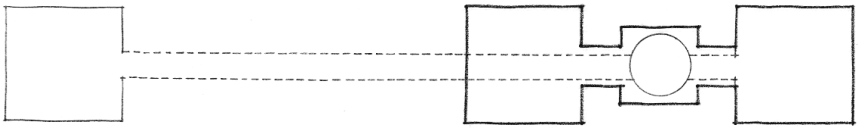


Two spaces that are separated by distance can be linked or related to each other by a third, intermediate, space. The visual and spatial relationship between the two spaces depends on the nature of the third space with which they share a common bond.

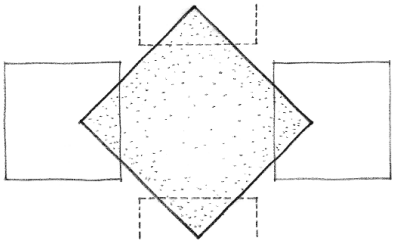
The intermediate space can differ in form and orientation from the two spaces to express its linking function.



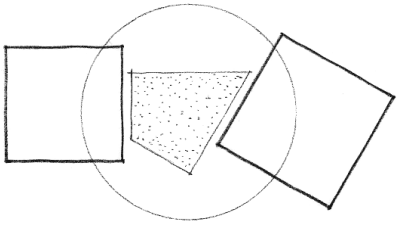
The two spaces, as well as the intermediate space, can be equivalent in size and shape and form a linear sequence of spaces.



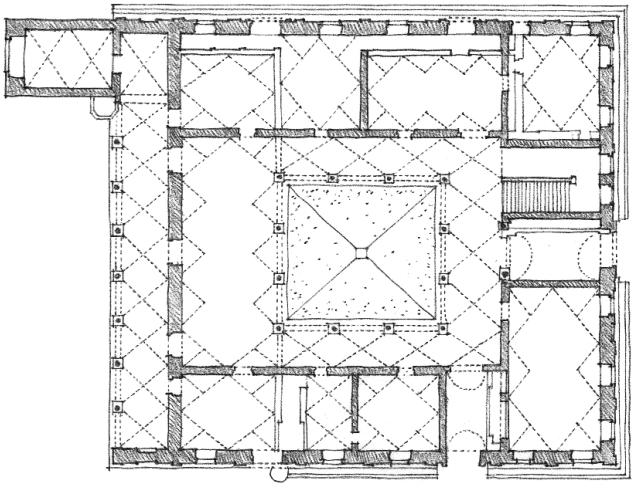
The intermediate space can itself become linear in form to link two spaces that are distant from each other, or join a whole series of spaces that have no direct relationship to one another.



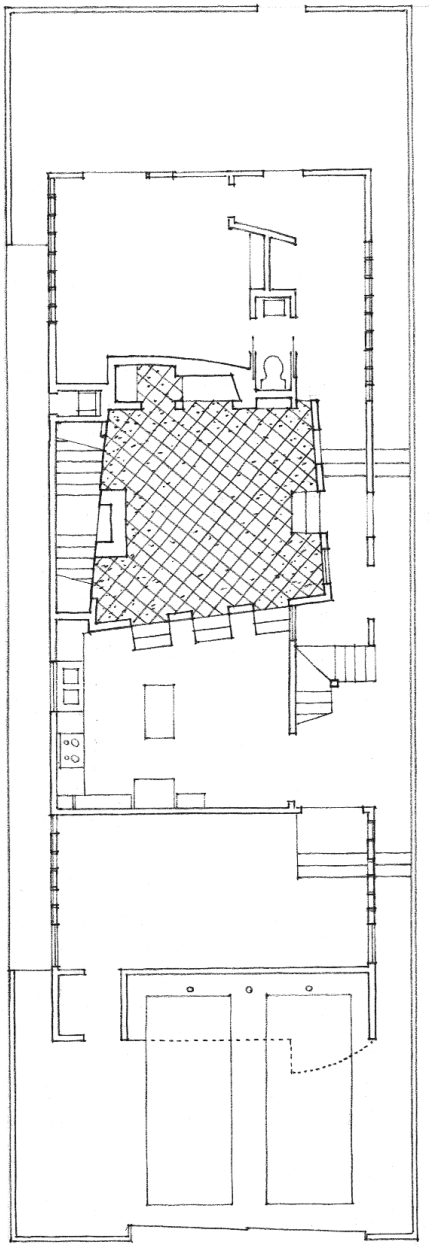
The intermediate space can, if large enough, become the dominant space in the relationship, and be capable of organizing a number of spaces about itself.



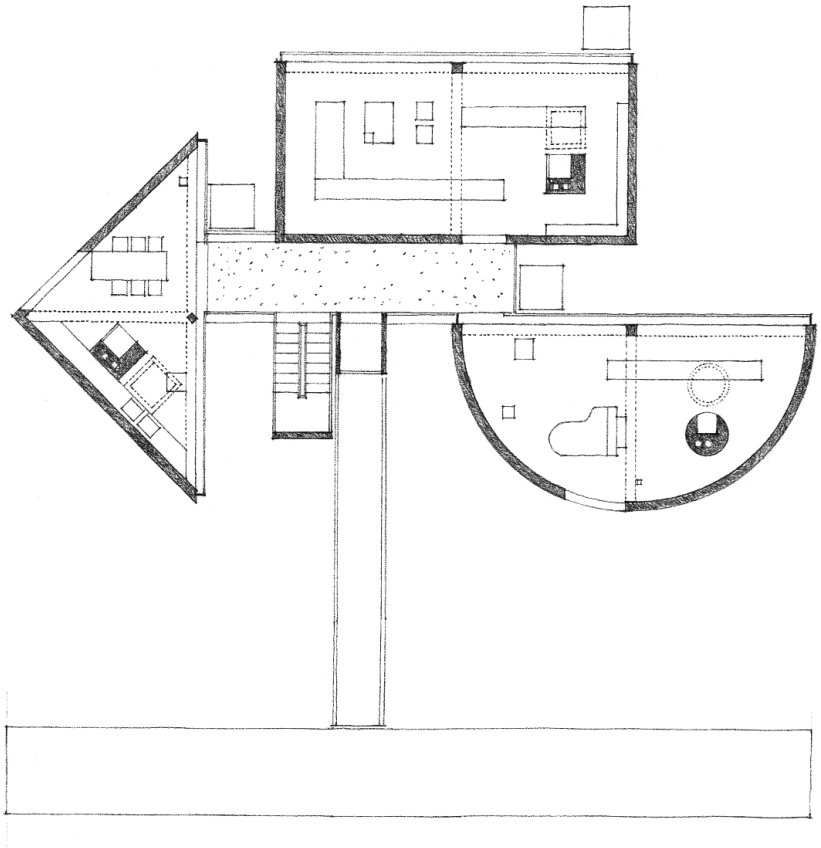
The form of the intermediate space can be residual in nature and be determined solely by the forms and orientations of the two spaces being linked.



Palazzo Piccolomini, Pienza, Italy, c. 1460, Bernardo Rosselino

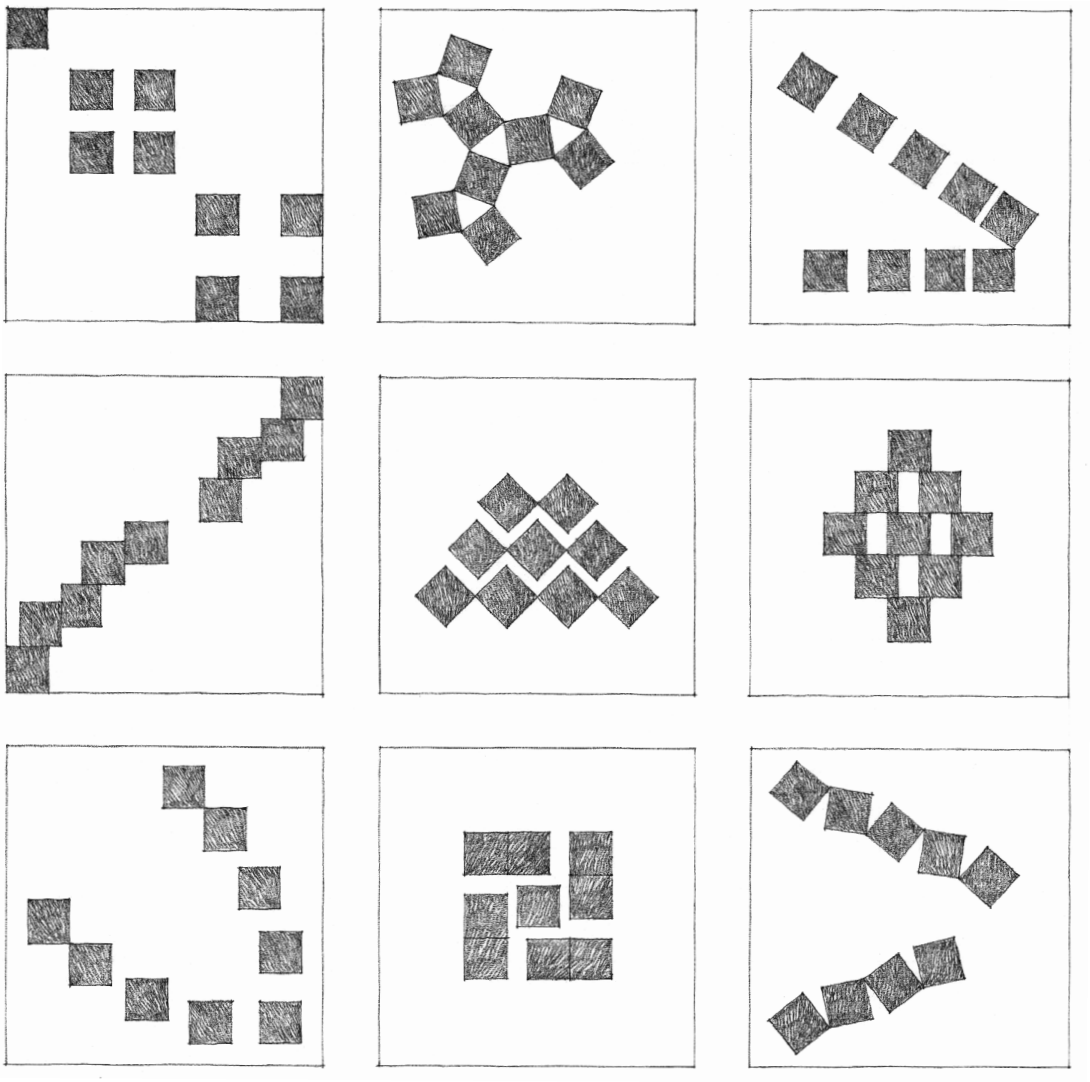


Caplin House, Venice, California, 1979, Frederick Fisher



One-Half House (Project), 1966, John Hejduk

SPATIAL ORGANIZATIONS



Compositions of Nine Squares:
A Bauhaus Study

The following section lays out the basic ways we can arrange and organize the spaces of a building. In a typical building program, there are usually requirements for various kinds of spaces. There may be requirements for spaces that:

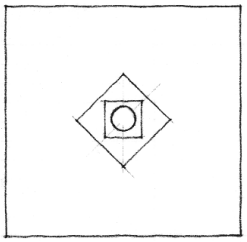
- Have specific functions or require specific forms
- Are flexible in use and can be freely manipulated
- Are singular and unique in their function or significance to the building organization
- Have similar functions and can be grouped into a functional cluster or repeated in a linear sequence
- Require exterior exposure for light, ventilation, outlook, or access to outdoor spaces
- Must be segregated for privacy
- Must be easily accessible

The manner in which these spaces are arranged can clarify their relative importance and functional or symbolic role in the organization of a building. The decision as to what type of organization to use in a specific situation will depend on:

- Demands of the building program, such as functional proximities, dimensional requirements, hierarchical classification of spaces, and requirements for access, light, or view
- Exterior conditions of the site that might limit the organization's form or growth, or that might encourage the organization to address certain features of its site and turn away from others

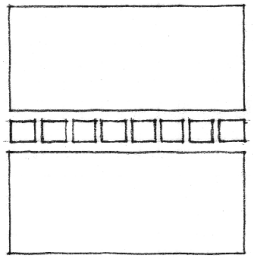
Each type of spatial organization is introduced by a section that discusses the formal characteristics, spatial relationships, and contextual responses of the category. A range of examples then illustrates the basic points made in the introduction. Each of the examples should be studied in terms of:

- What kinds of spaces are accommodated and where? How are they defined?
- What kinds of relationships are established among the spaces, one to another, and to the exterior environment?
- Where can the organization be entered, and what configuration does the path of circulation have?
- What is the exterior form of the organization, and how might it respond to its context?



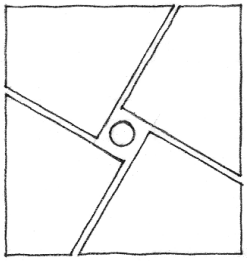
Centralized Organization

A central, dominant space about which a number of secondary spaces are grouped



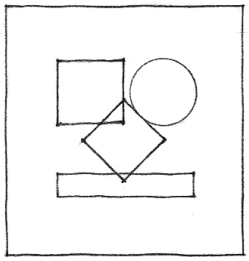
Linear Organization

A linear sequence of repetitive spaces



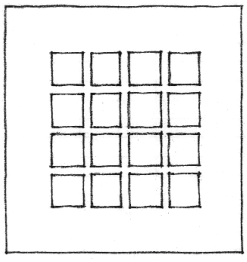
Radial Organization

A central space from which linear organizations of space extend in a radial manner



Clustered Organization

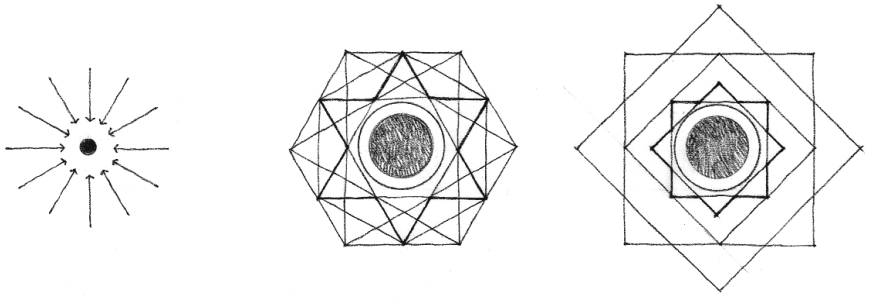
Spaces grouped by proximity or the sharing of a common visual trait or relationship



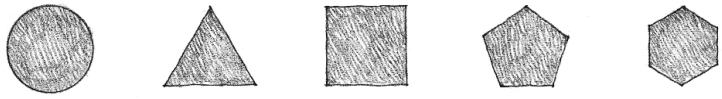
Grid Organization

Spaces organized within the field of a structural grid or other three-dimensional framework

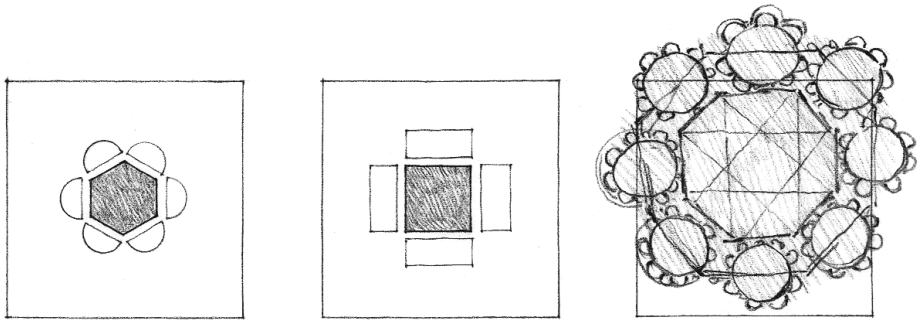
CENTRALIZED ORGANIZATIONS



A centralized organization is a stable, concentrated composition that consists of a number of secondary spaces grouped around a large, dominant, central space.

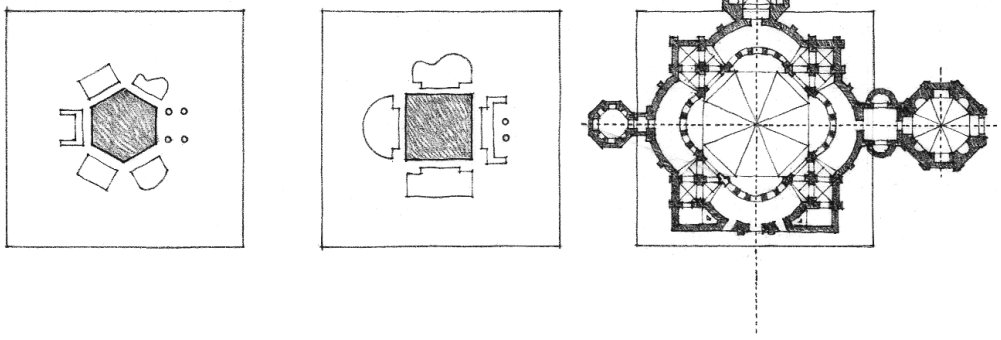


The central, unifying space of the organization is generally regular in form and large enough in size to gather a number of secondary spaces about its perimeter.



Ideal Church by Leonardo da Vinci

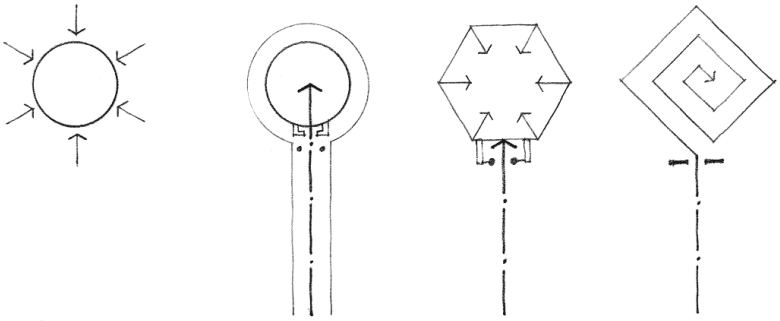
The secondary spaces of the organization may be equivalent to one another in function, form, and size, and create an overall configuration that is geometrically regular and symmetrical about two or more axes.



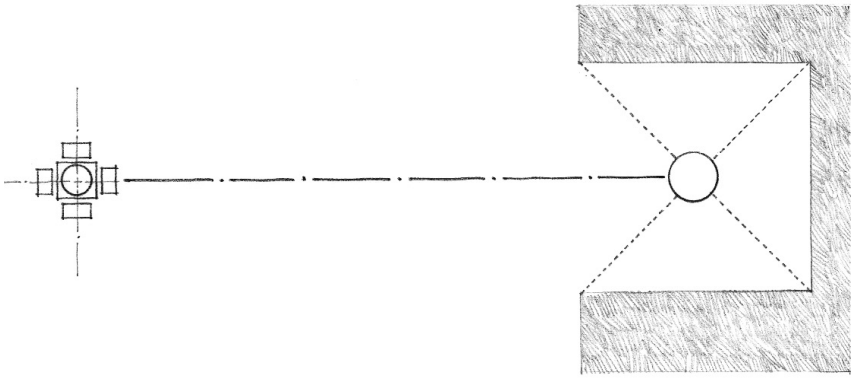
San Lorenzo Maggiore, Milan, Italy, c. A.D. 480

The secondary spaces may differ from one another in form or size in order to respond to individual requirements of function, express their relative importance, or acknowledge their surroundings. This differentiation among the secondary spaces also allows the form of a centralized organization to respond to the environmental conditions of its site.

Since the form of a centralized organization is inherently nondirectional, conditions of approach and entry must be specified by the site and the articulation of one of the secondary spaces as an entrance or gateway.



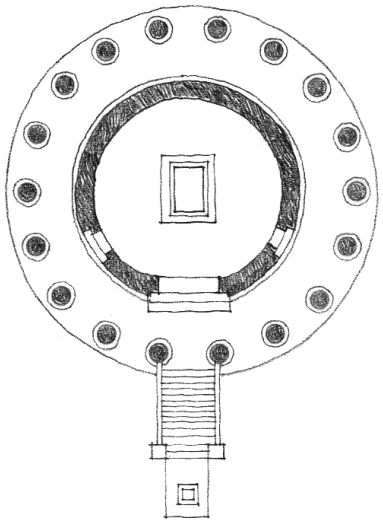
The pattern of circulation and movement within a centralized organization may be radial, loop, or spiral in form. In almost every case, however, the pattern will terminate in or around the central space.

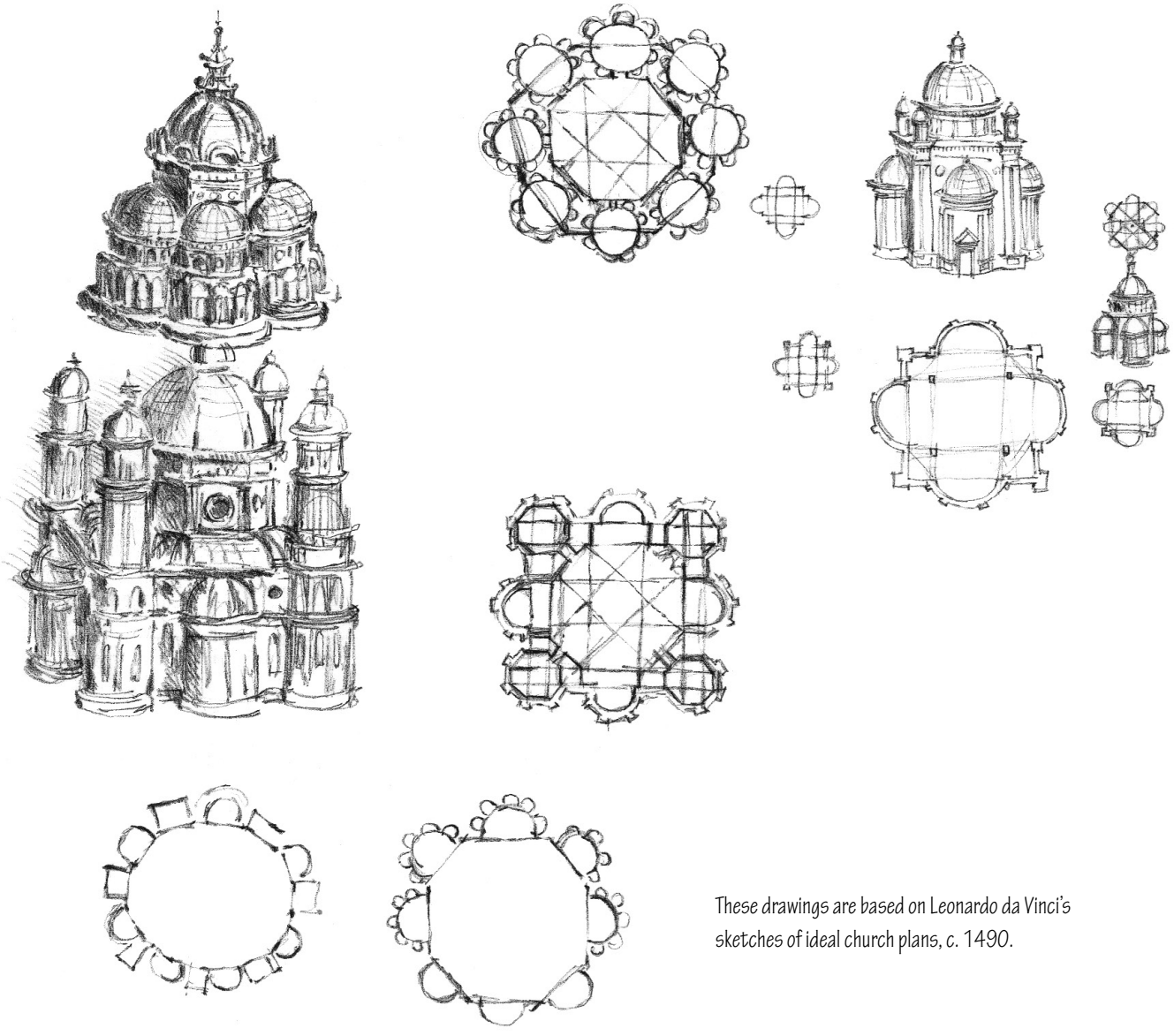


Centralized organizations whose forms are relatively compact and geometrically regular can be used to:

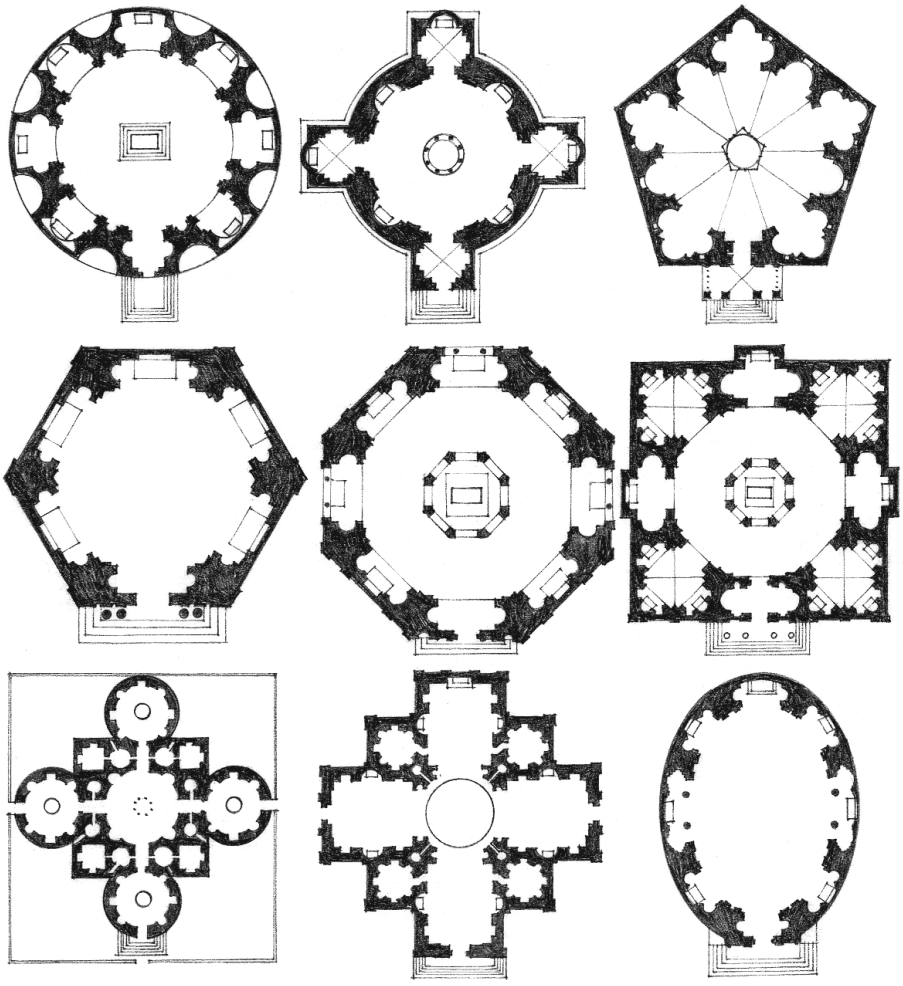
- Establish points or places in space.
- Terminate axial conditions.
- Serve as an object-form within a defined field or volume of space.

The central organizing space may be either an interior or an exterior space.

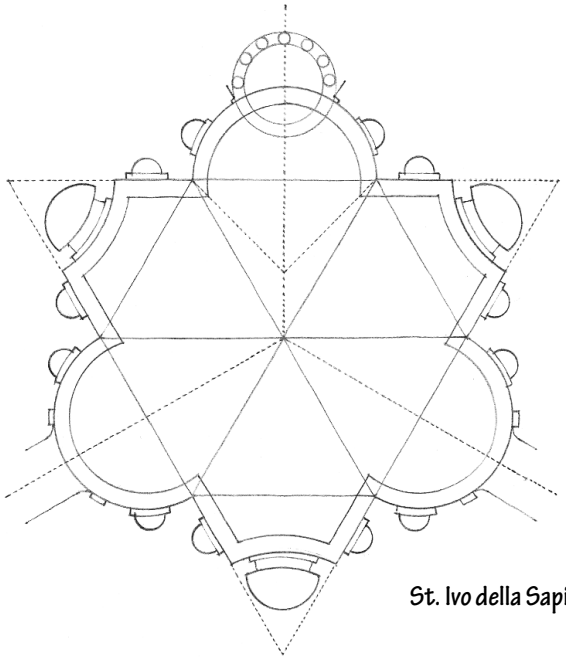




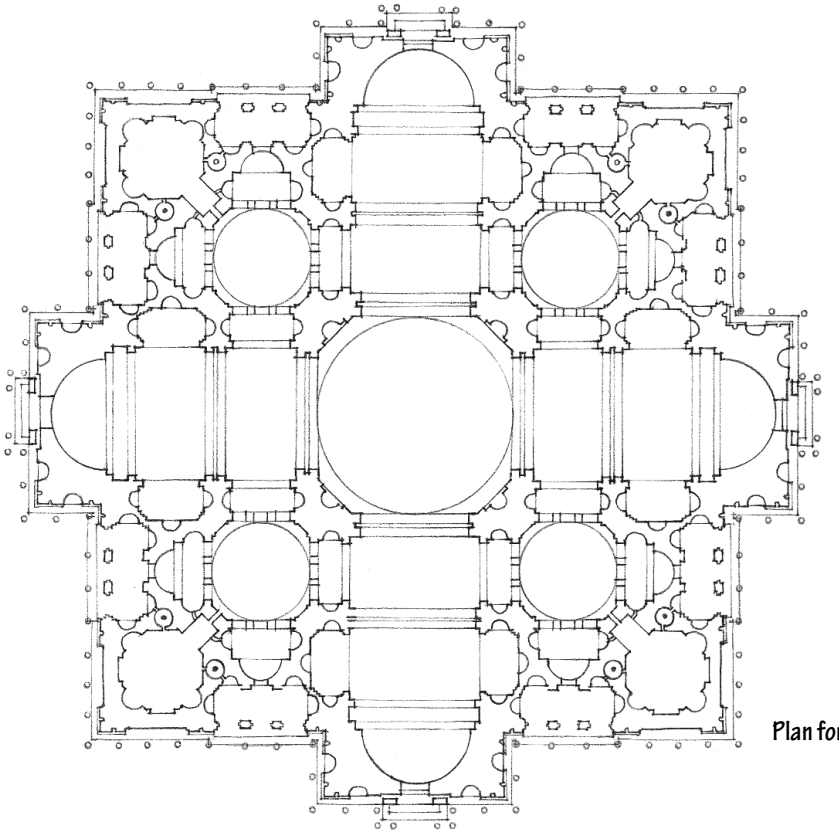
These drawings are based on Leonardo da Vinci's sketches of ideal church plans, c. 1490.

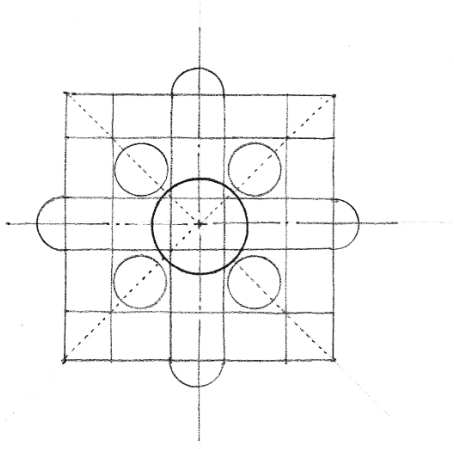


Centralized Plans, 1547, *Sebastiano Serlio*

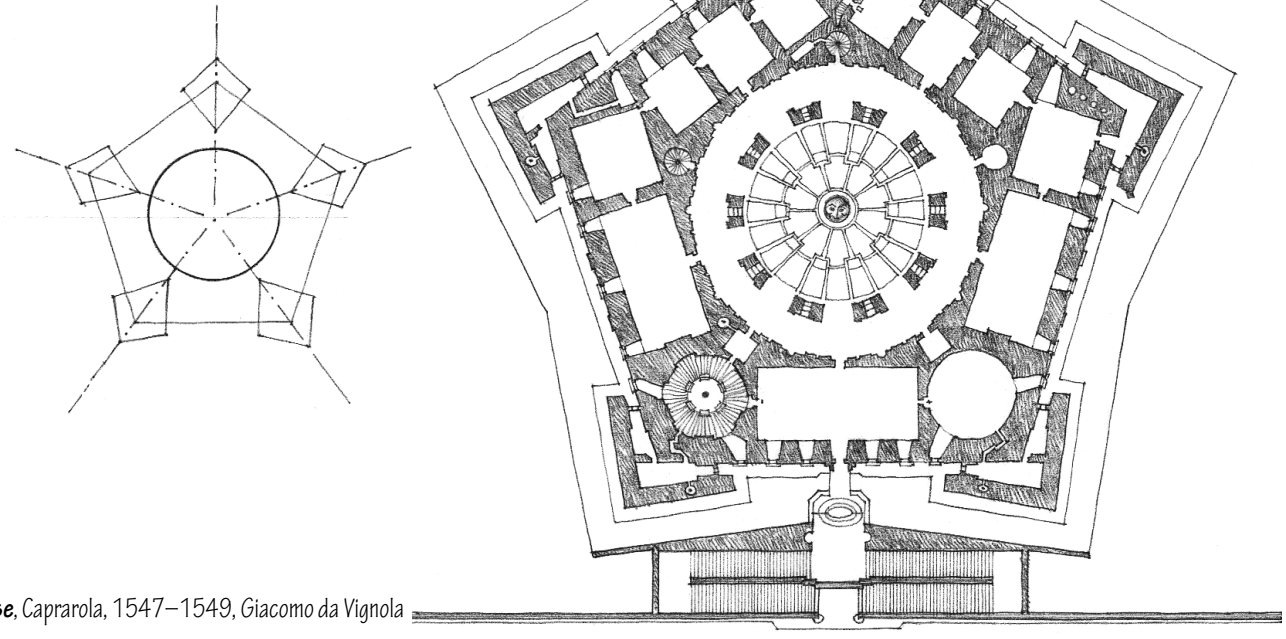


St. Ivo della Sapienze, *Rome, 1642–1650, Francesco Borromini*

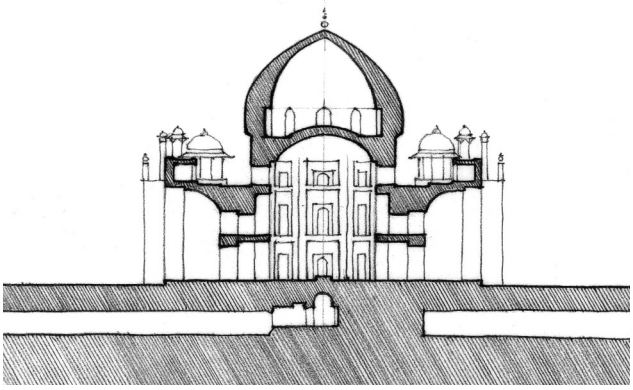


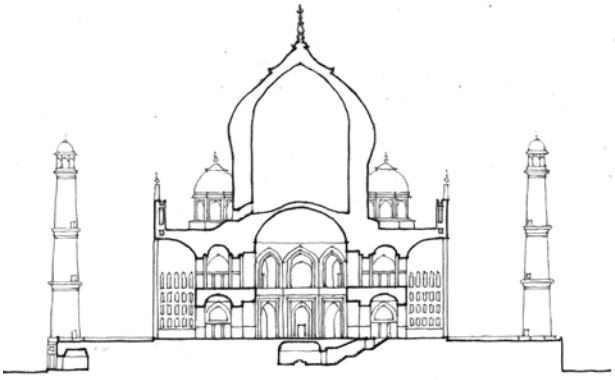


Plan for St. Peter's (First Version), Rome, c. 1503, Donato Bramante

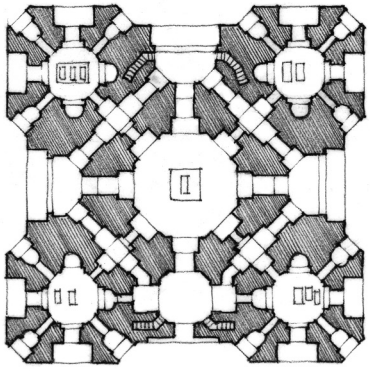


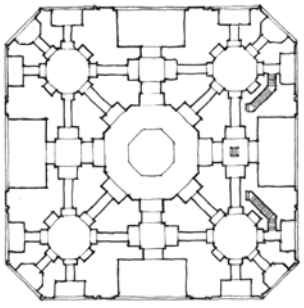
Villa Farnese, Caprarola, 1547–1549, Giacomo da Vignola



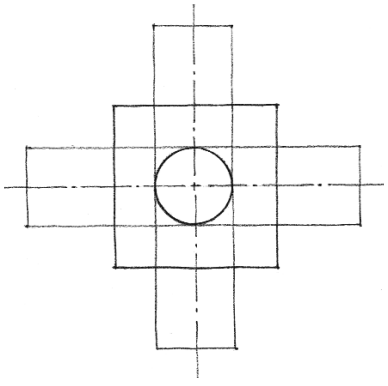


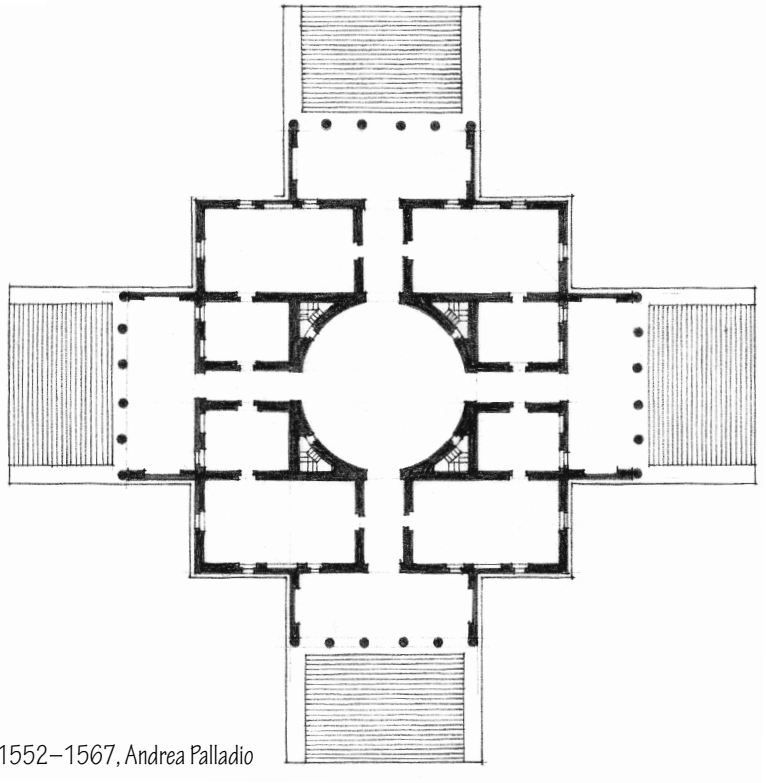
Taj Mahal, Agra, India, 1632–1654



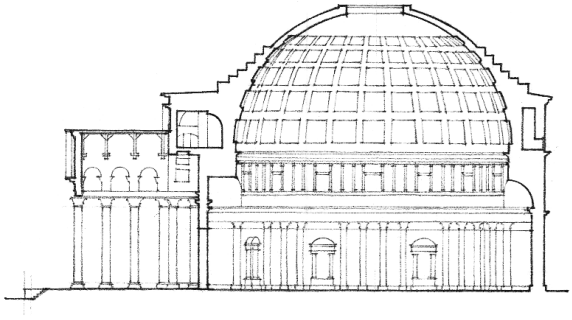


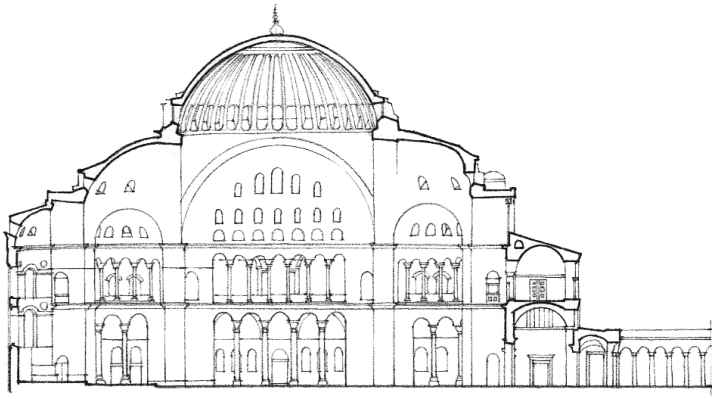
Humayun's Tomb, Delhi, India, 1565, Mirak Mirza Ghiyas

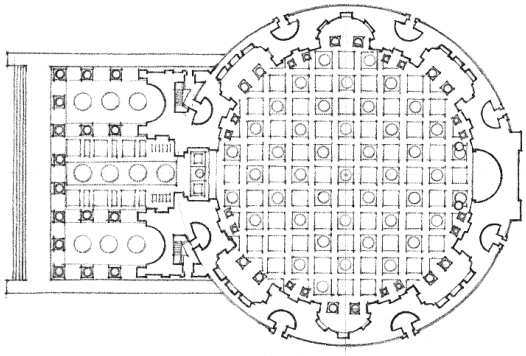


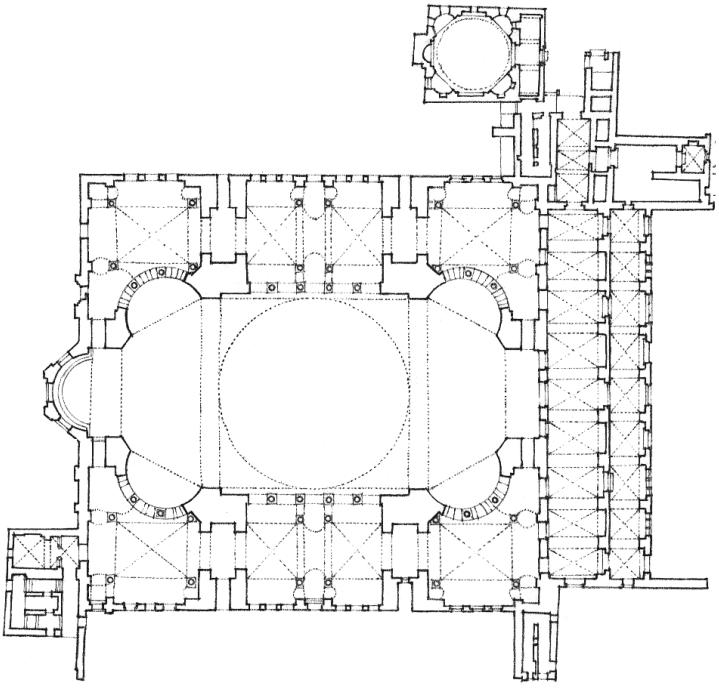


Villa Capra (The Rotunda), Vicenza, Italy, 1552–1567, Andrea Palladio



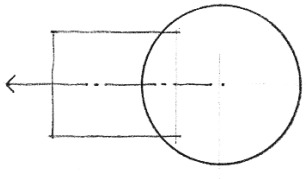


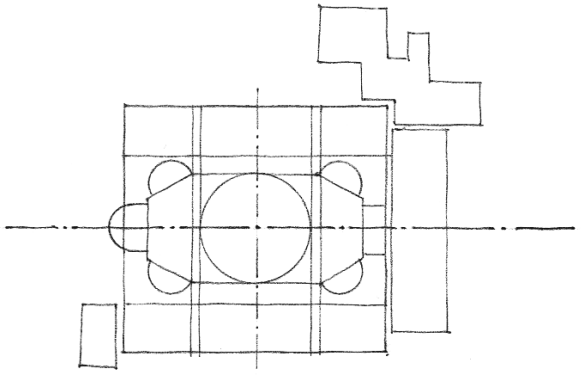


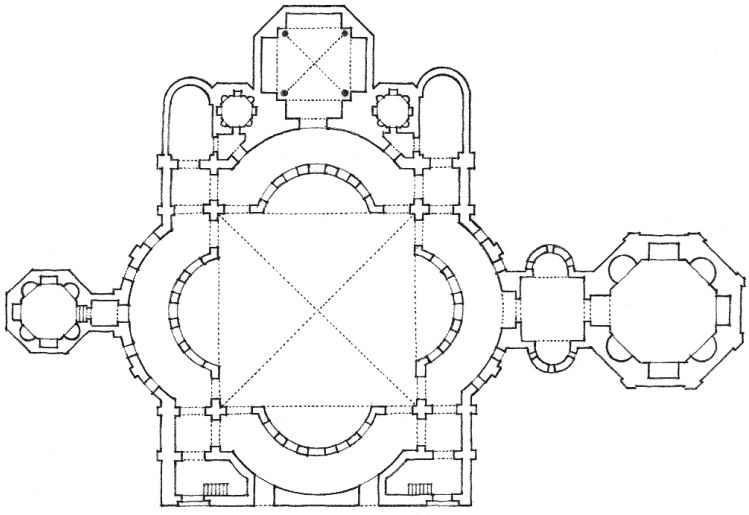


The Pantheon, Rome, A.D. 120–124. Portico from temple of 25 B.C.

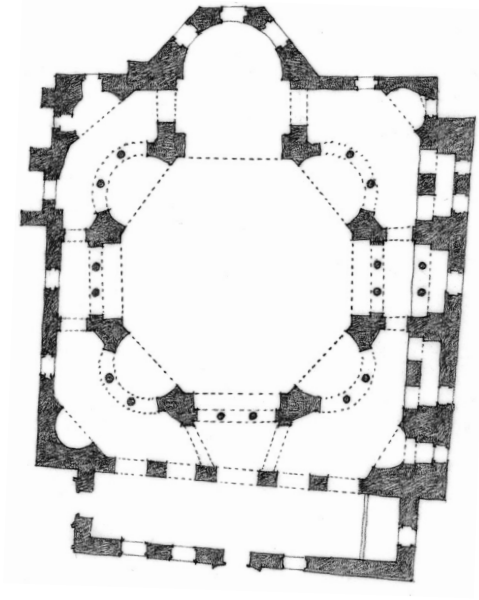
Hagia Sophia, Constantinople (Istanbul), A.D. 532–537, Anthemius of Tralles and Isidorus of Miletus



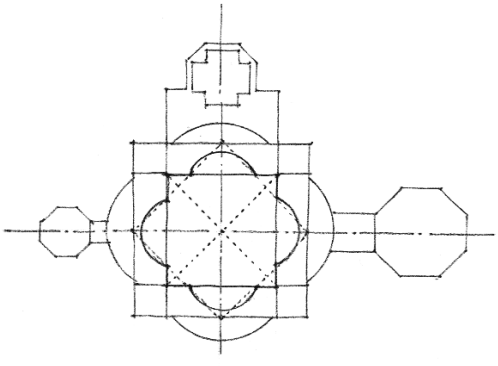


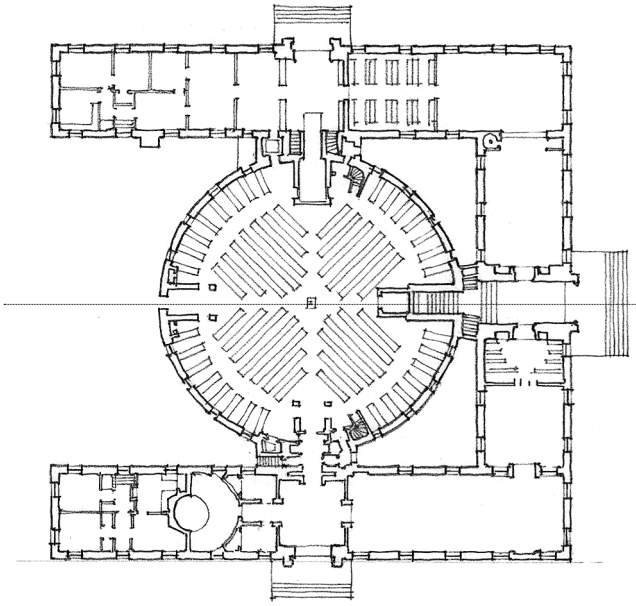


San Lorenzo Maggiore, Milan, Italy, *c.* A.D. 480

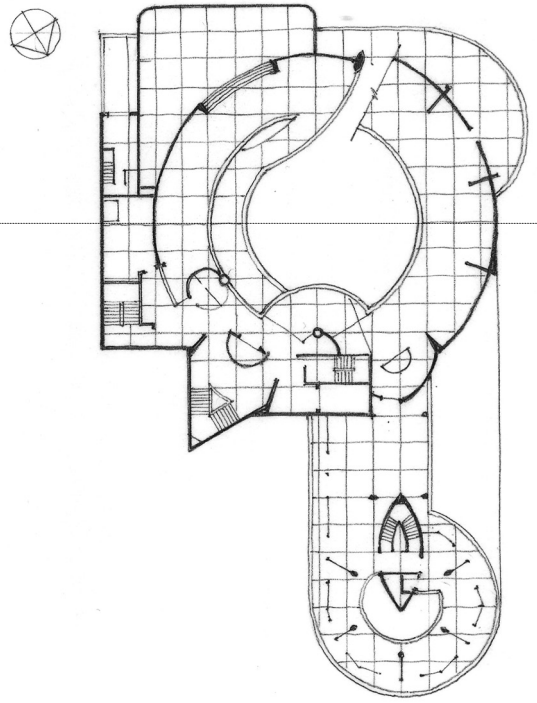


SS. Sergio and Bacchus, Constantinople (Istanbul), Turkey, A.D. 525–530

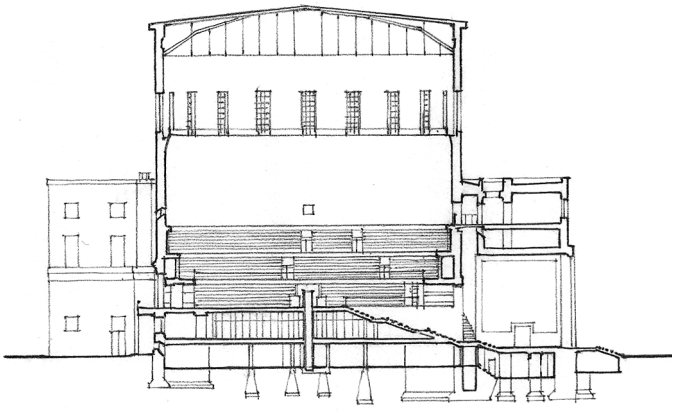


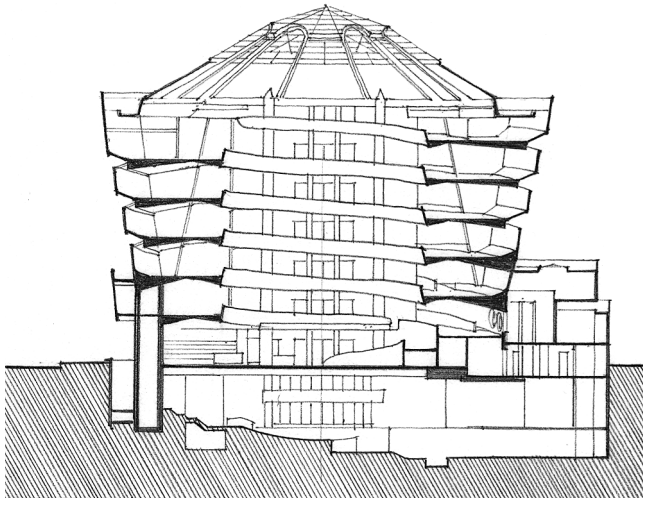


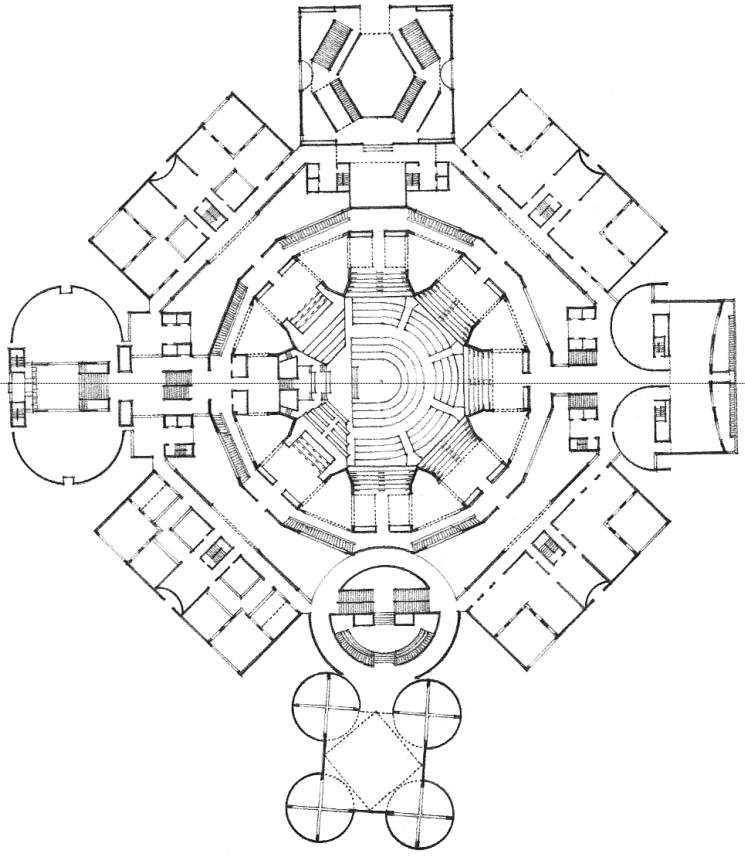
Stockholm Public Library, 1920–1928, Gunnar Asplund



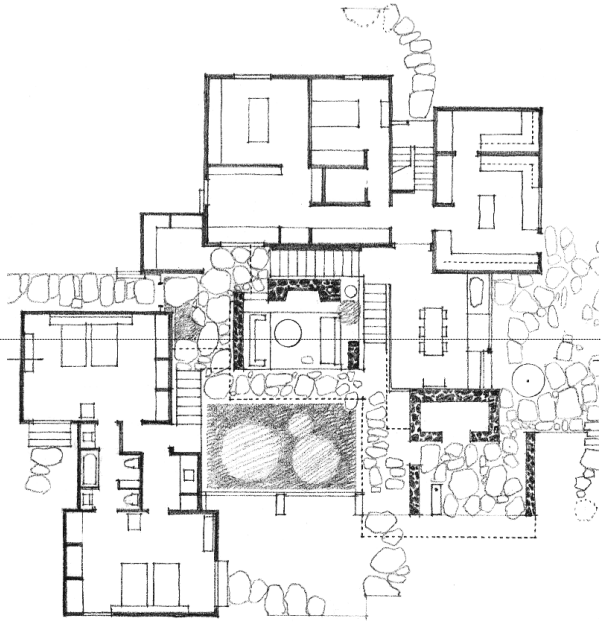
Guggenheim Museum, New York City, 1943–1959, Frank Lloyd Wright



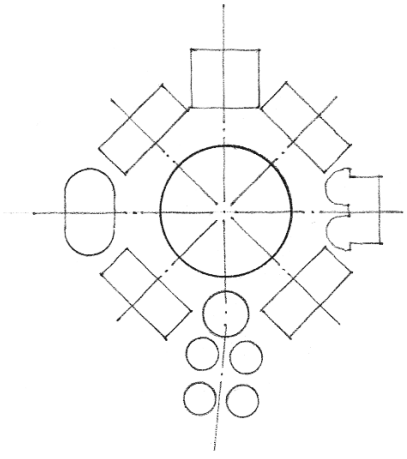


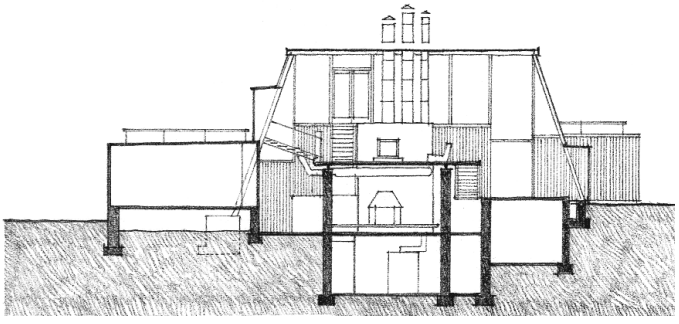


National Assembly Building, Capitol Complex at Dacca, Bangladesh, begun 1962, Louis Kahn

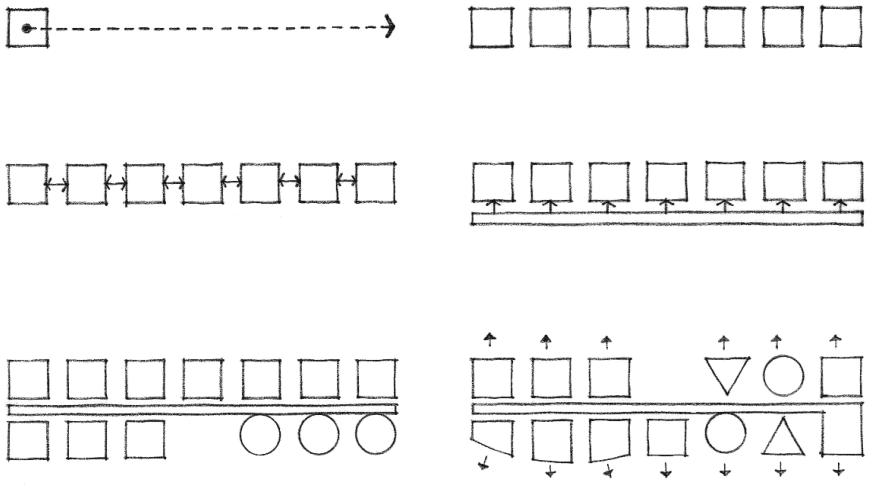


Greenhouse House, Salisbury, Connecticut, 1973–1975, John M. Johansen



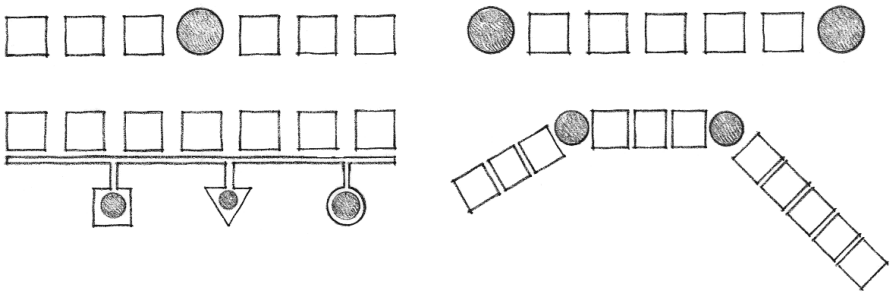


LINEAR ORGANIZATIONS



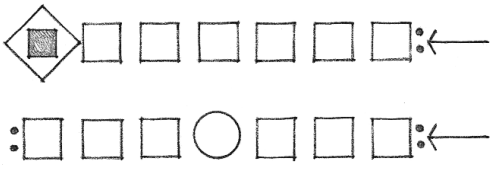
A linear organization consists essentially of a series of spaces. These spaces can either be directly related to one another or be linked through a separate and distinct linear space.

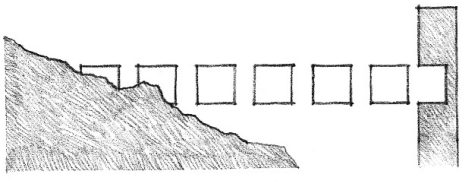
A linear organization usually consists of repetitive spaces that are alike in size, form, and function. It may also consist of a single linear space that organizes along its length a series of spaces that differ in size, form, or function. In both cases, each space along the sequence has an exterior exposure.



Spaces that are functionally or symbolically important to the organization can occur anywhere along the linear sequence and have their importance articulated by their size and form. Their significance can also be emphasized by their location:

- At the end of the linear sequence
- Offset from the linear organization
- At pivotal points of a segmented linear form

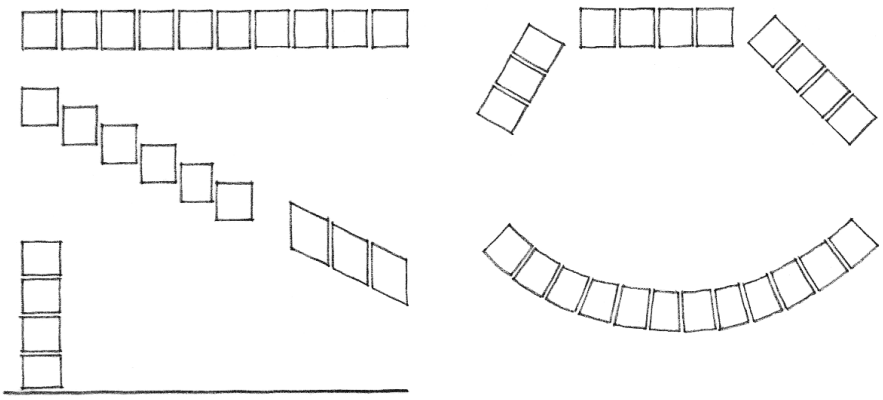




Because of their characteristic length, linear organizations express a direction and signify movement, extension, and growth. To limit their growth, linear organizations can be terminated by a dominant space or form, by an elaborate or articulated entrance, or by merging with another building form or the topography of its site.

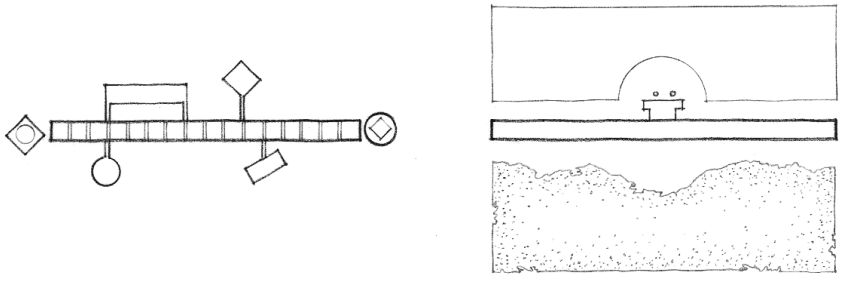
LINEAR ORGANIZATIONS

The form of a linear organization is inherently flexible and can respond readily to various conditions of its site. It can adapt to changes in topography, maneuver around a body of water or a stand of trees, or turn to orient spaces to capture sunlight and views. It can be straight, segmented, or curvilinear. It can run horizontally across its site, diagonally up a slope, or stand vertically as a tower.

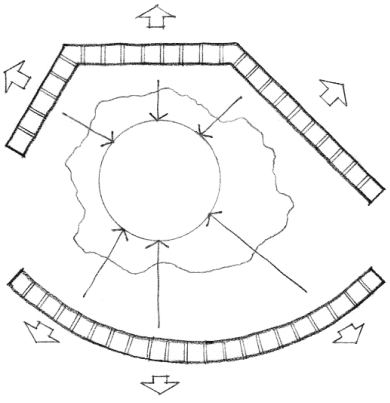


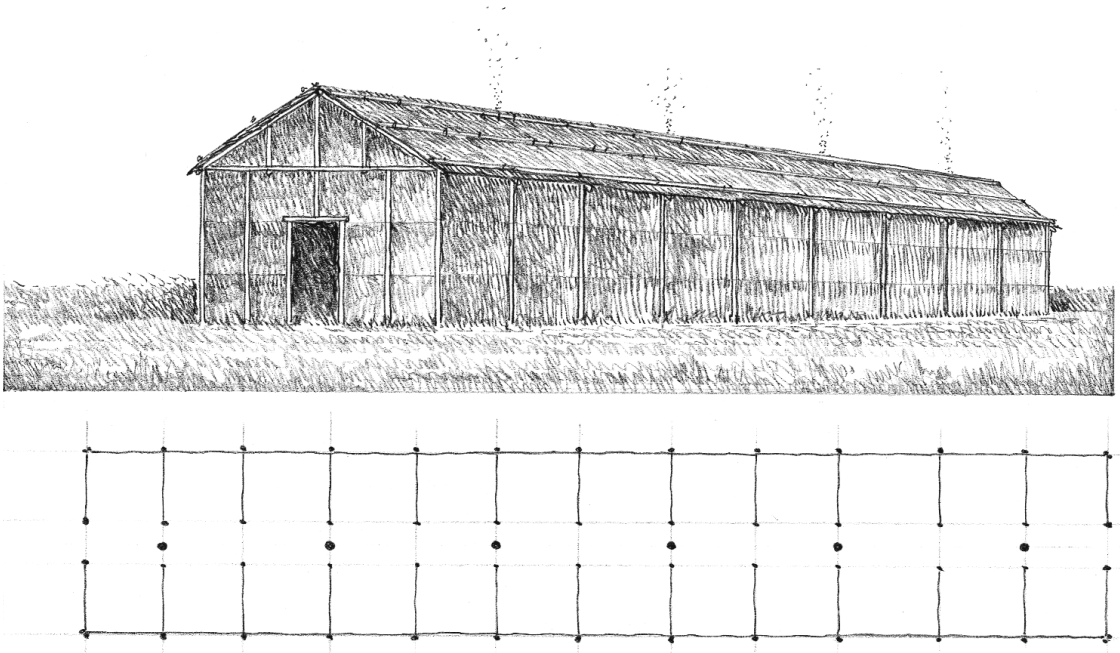
The form of a linear organization can relate to other forms in its context by:

- Linking and organizing them along its length
- Serving as a wall or barrier to separate them into different fields
- Surrounding and enclosing them within a field of space

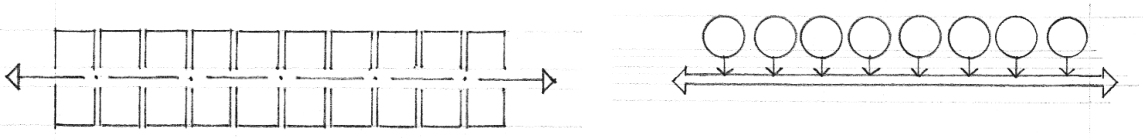


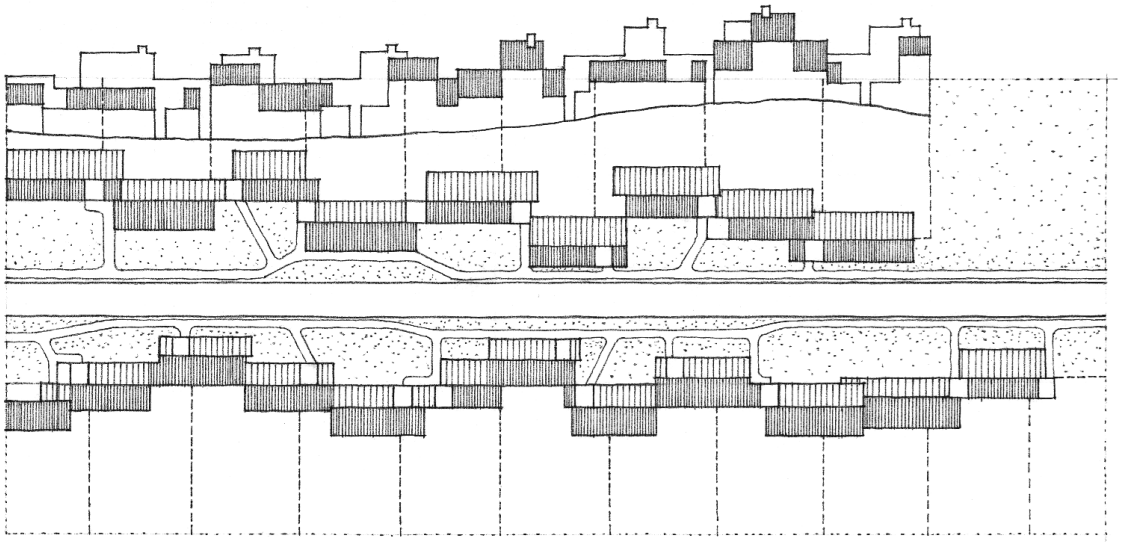
Curved and segmented forms of linear organizations enclose a field of exterior space on their concave sides and orient their spaces toward the center of the field. On their concave sides, these forms appear to front space and exclude it from their fields.



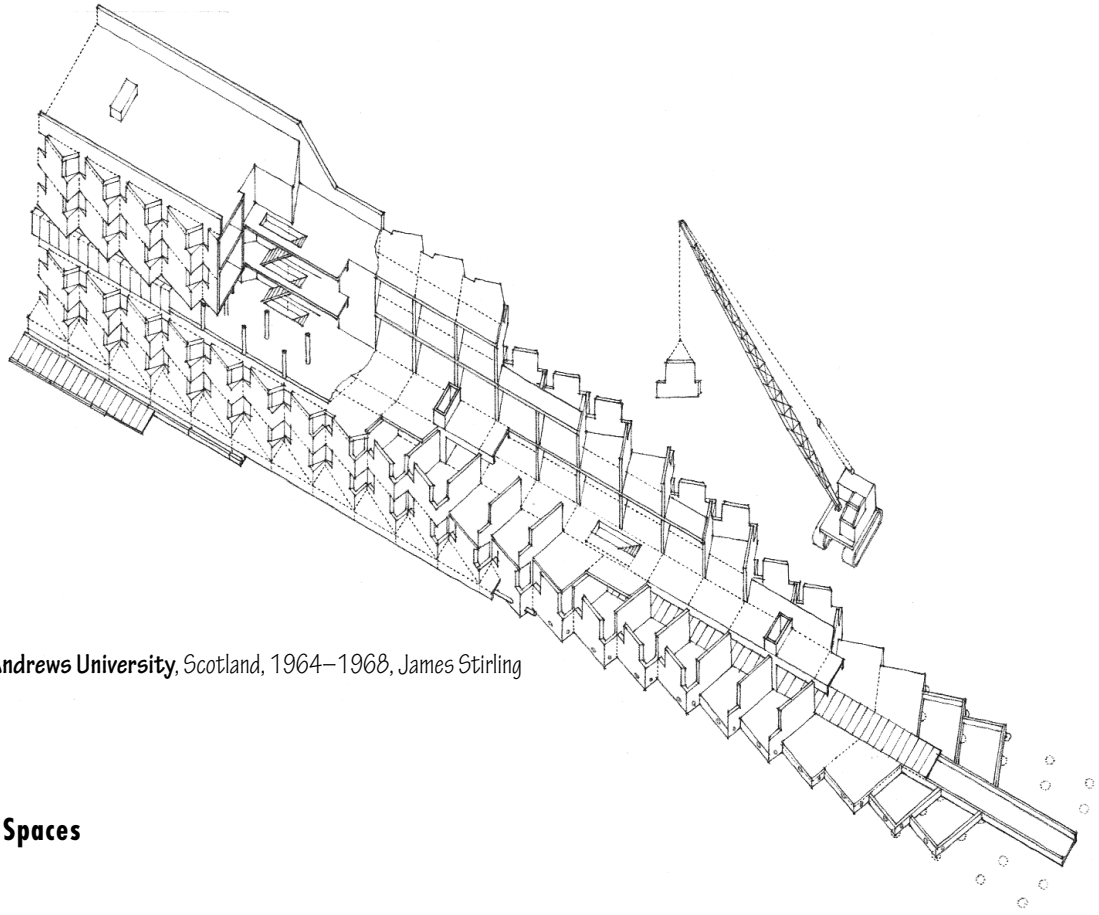


Longhouse, *a dwelling type of the member tribes of the Iroquois Confederacy in North America, c. 1600*



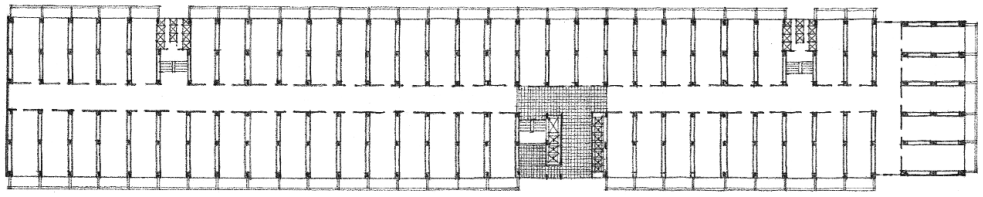


Terraced Housing Fronting a Village Street, **Village Project**, 1955, James Stirling (Team X)

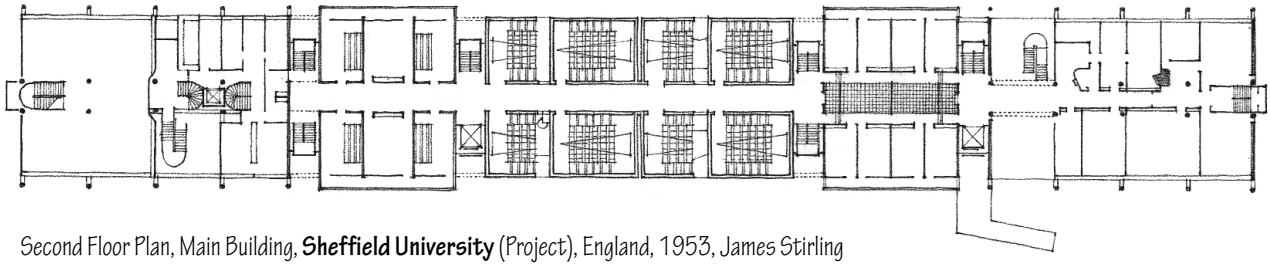


Residential Expansion, **St. Andrews University**, Scotland, 1964–1968, James Stirling

Linear Sequences of Spaces

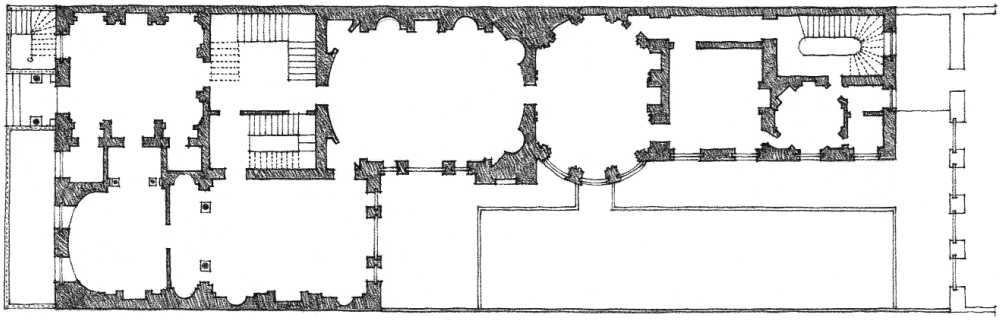


Typical Apartment Floor, **Unité d'Habitation**, Marseilles, 1946–1952, Le Corbusier

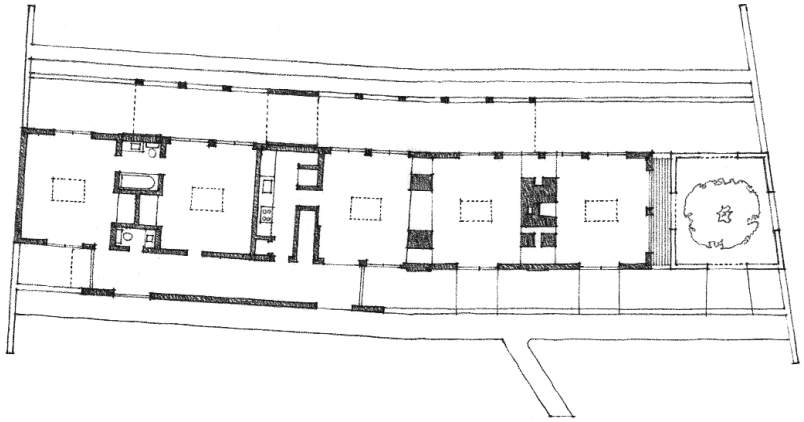


Second Floor Plan, Main Building, **Sheffield University** (Project), England, 1953, James Stirling

LINEAR ORGANIZATIONS

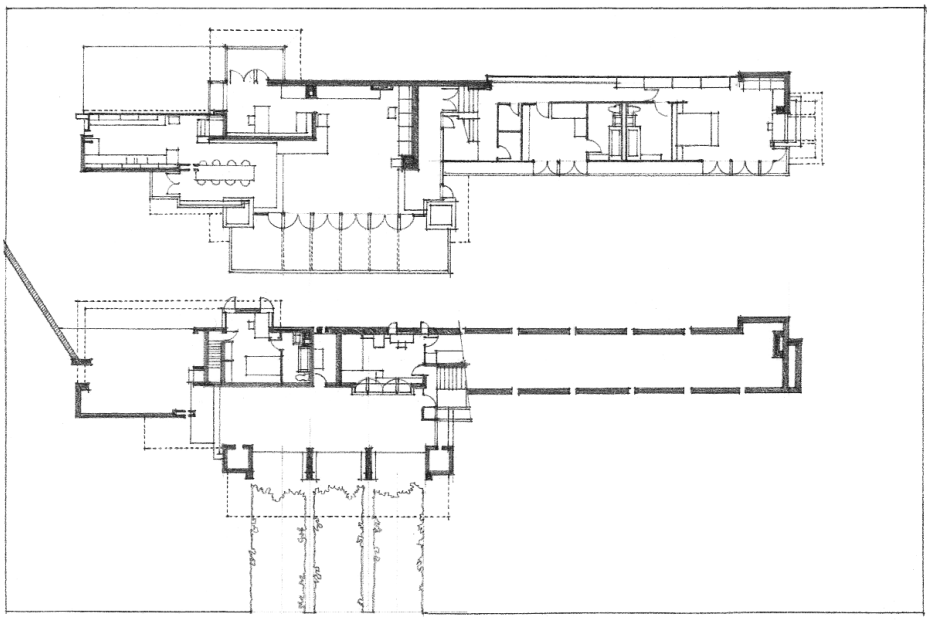


Lord Derby's House, London, 1777
Robert Adam

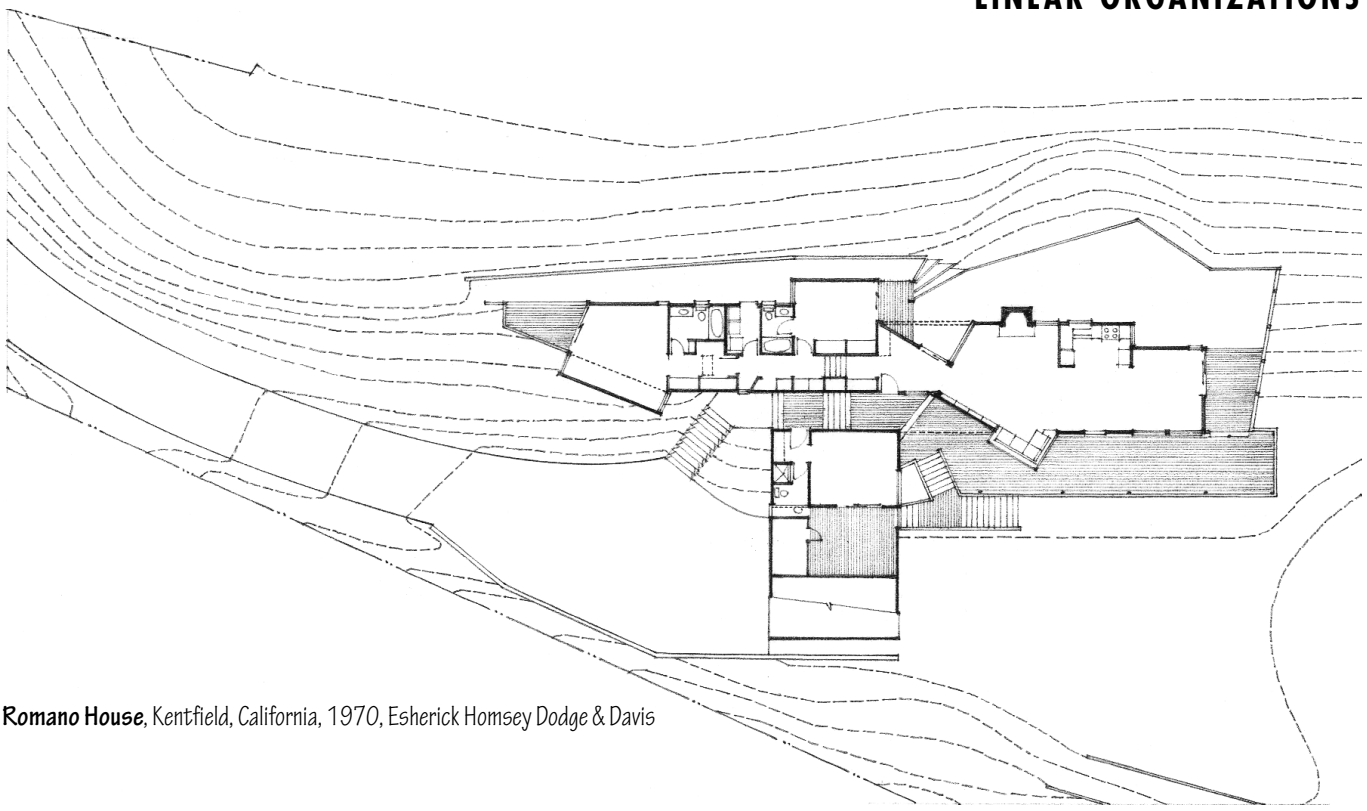


Pearson House (Project), 1957,
Robert Venturi

Linear Sequences of Rooms...

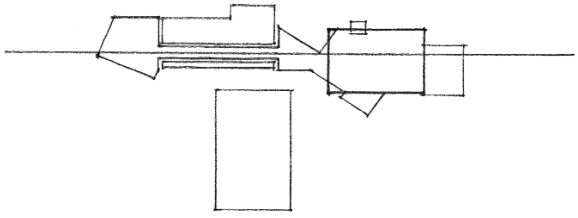


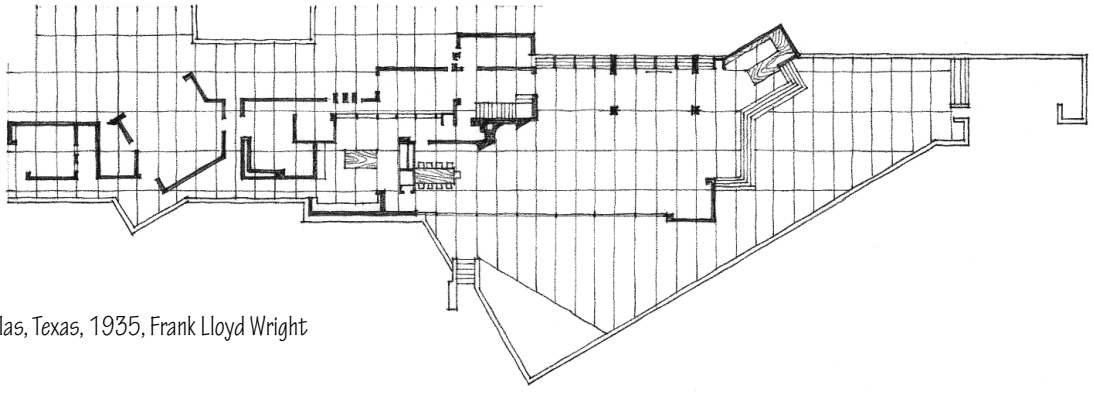
Lloyd Lewis House, Libertyville, Illinois,
1940, Frank Lloyd Wright



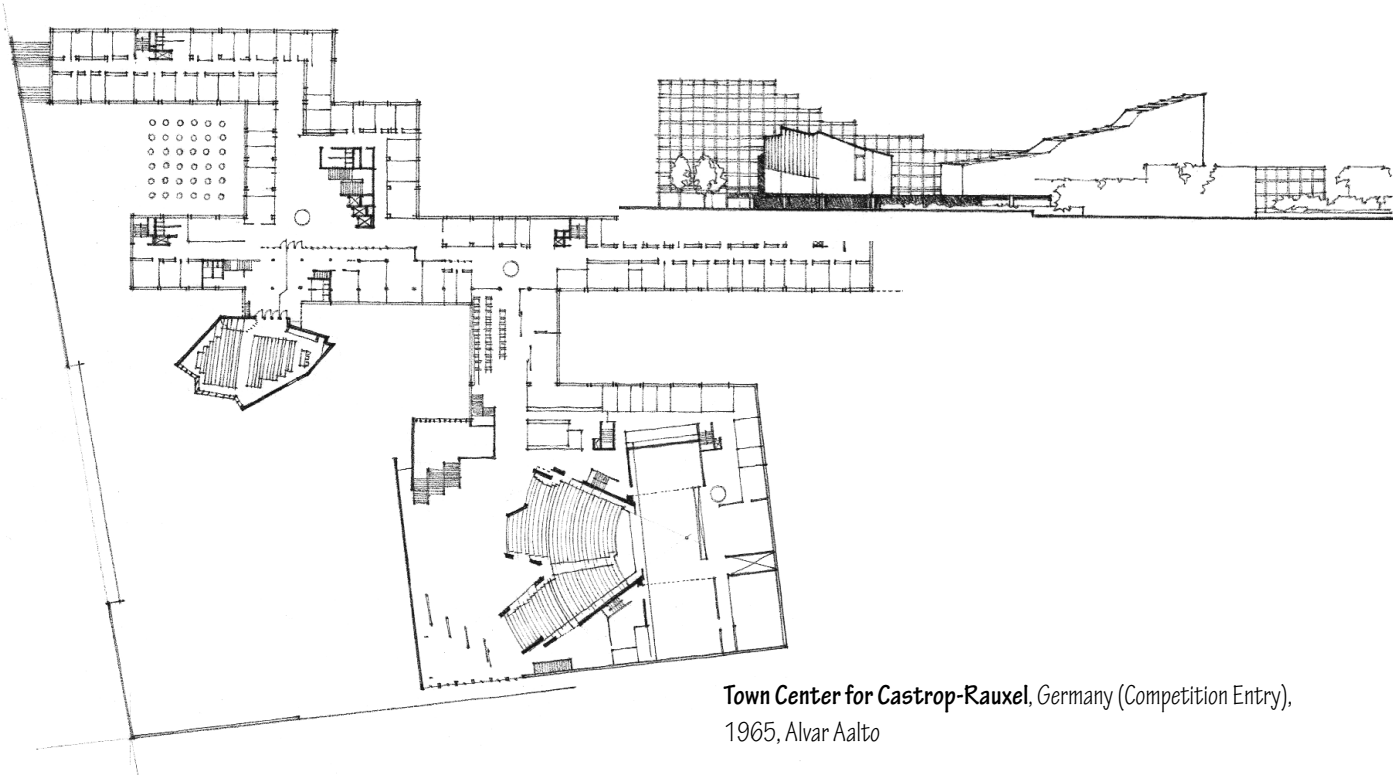
Romano House, Kentfield, California, 1970, Esherick Homsey Dodge & Davis

Adapting to Function and Site



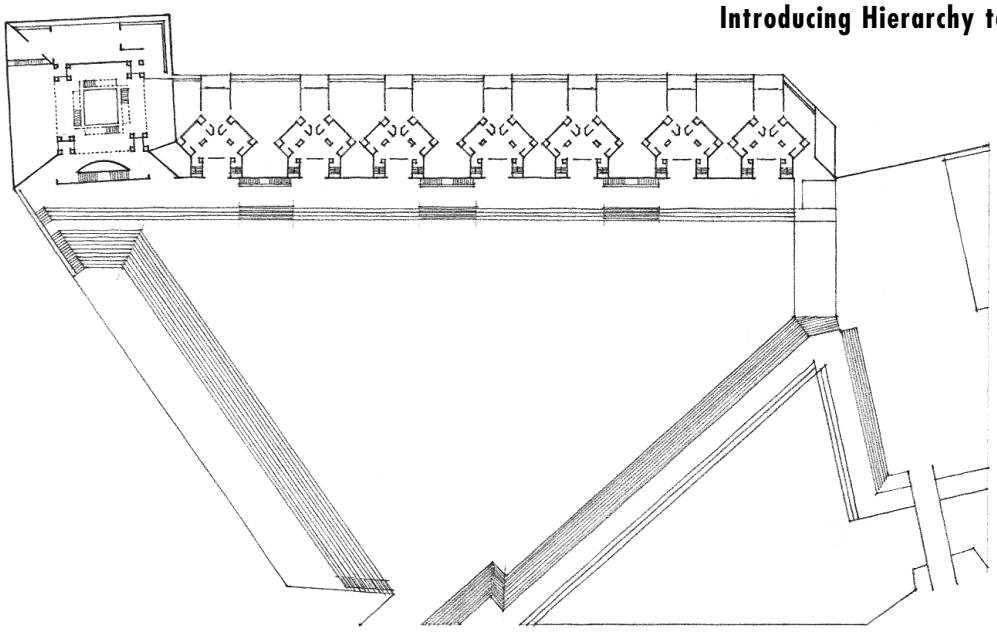


Marcus House (Project), Dallas, Texas, 1935, Frank Lloyd Wright

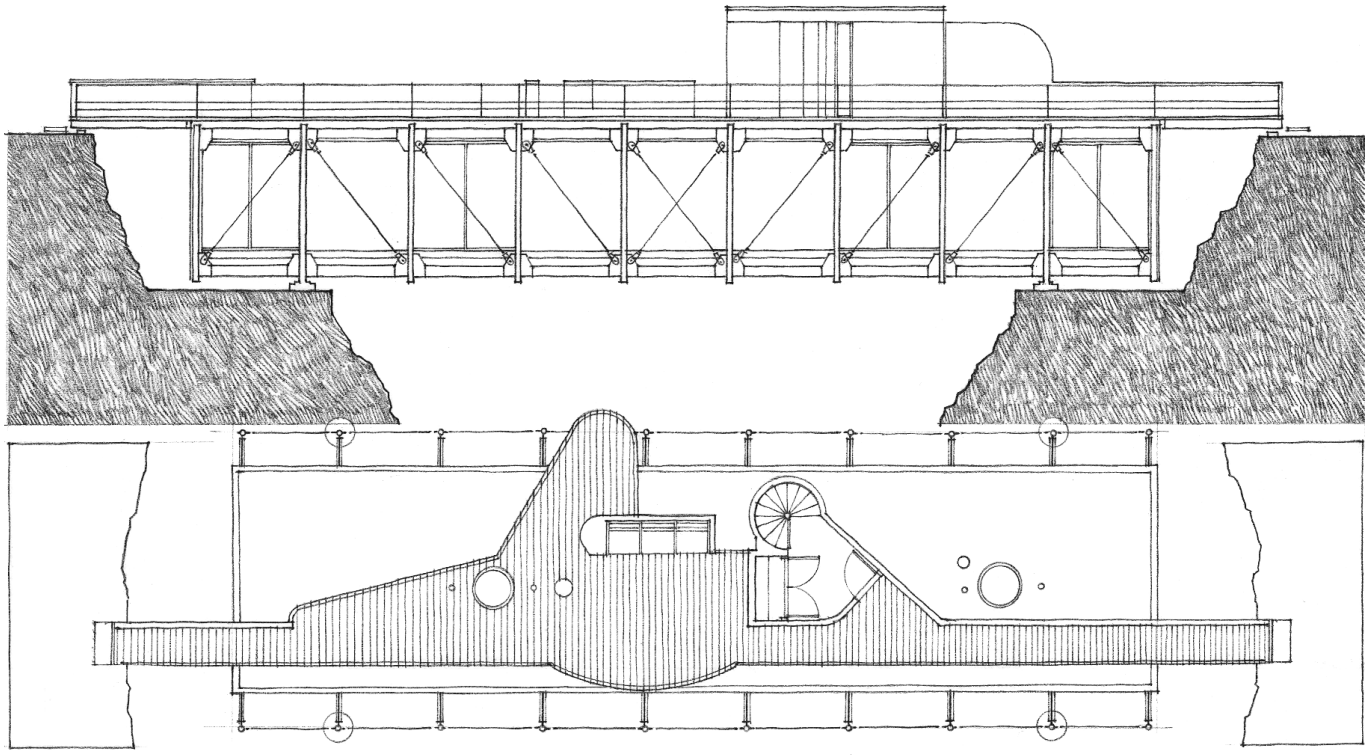


Town Center for Castrop-Rauxel, Germany (Competition Entry), 1965, Alvar Aalto

Introducing Hierarchy to Linear Sequences...

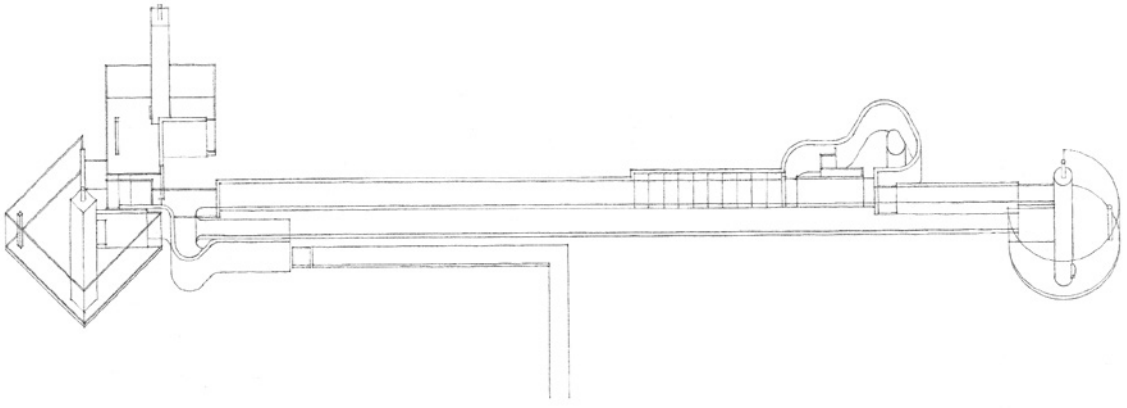


Interama, Project for an Inter-American Community, Florida, 1964–1967, Louis Kahn



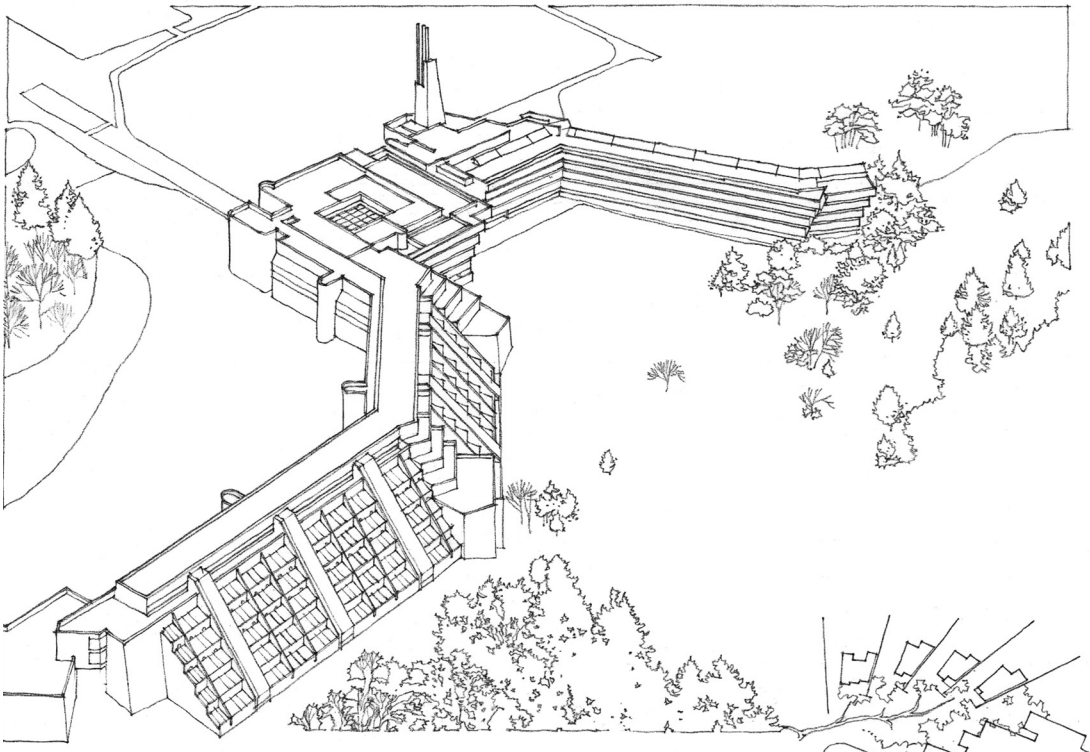
Bridge House (Project), Christopher Owen

and Expressing Movement

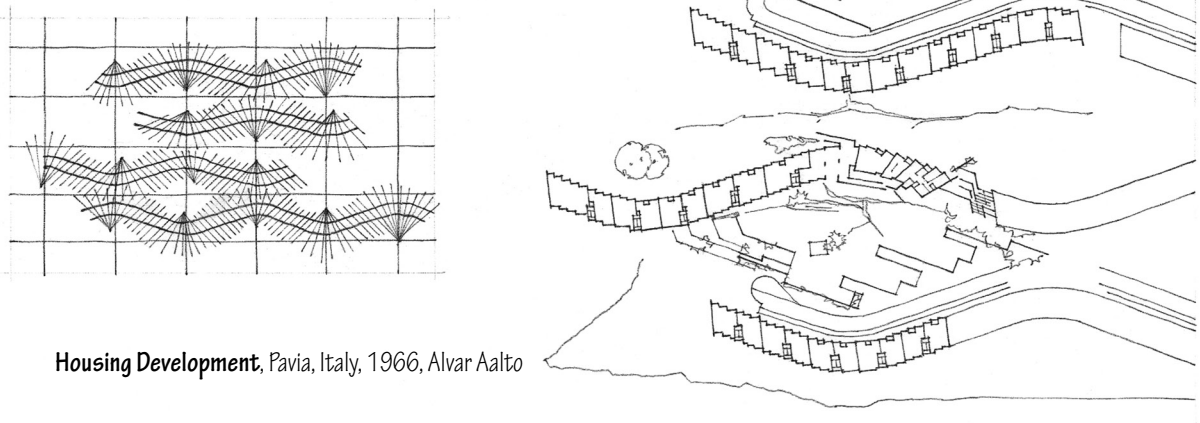


House 10 (Project), 1966, John Hejduk

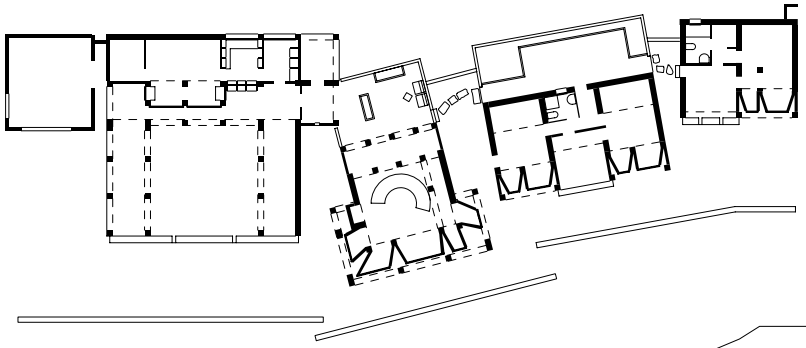
LINEAR ORGANIZATIONS



Scarborough College, Westhill, Ontario, 1964, John Andrews

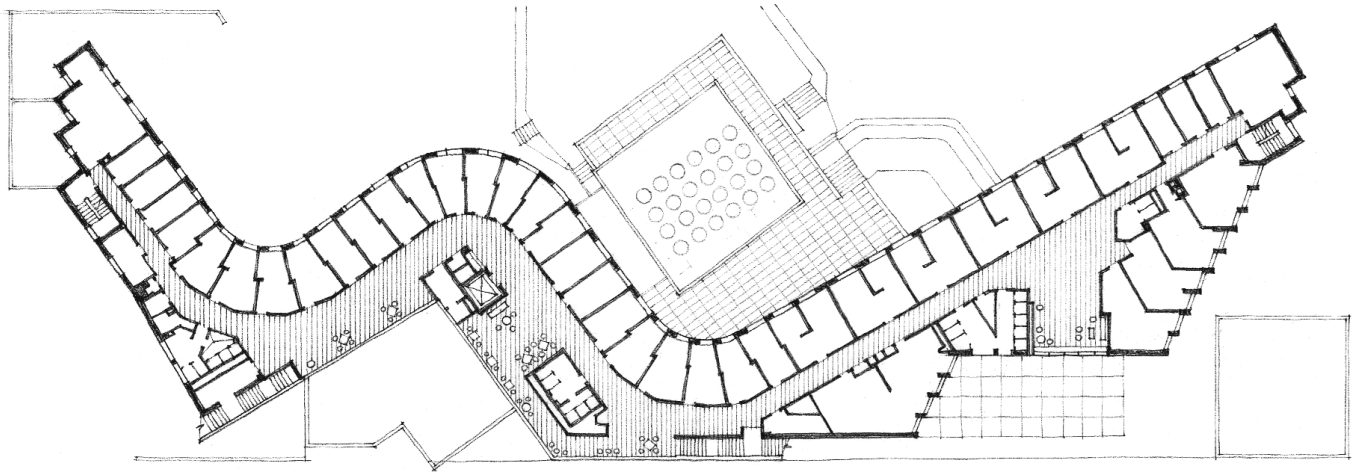


Housing Development, Pavia, Italy, 1966, Alvar Aalto

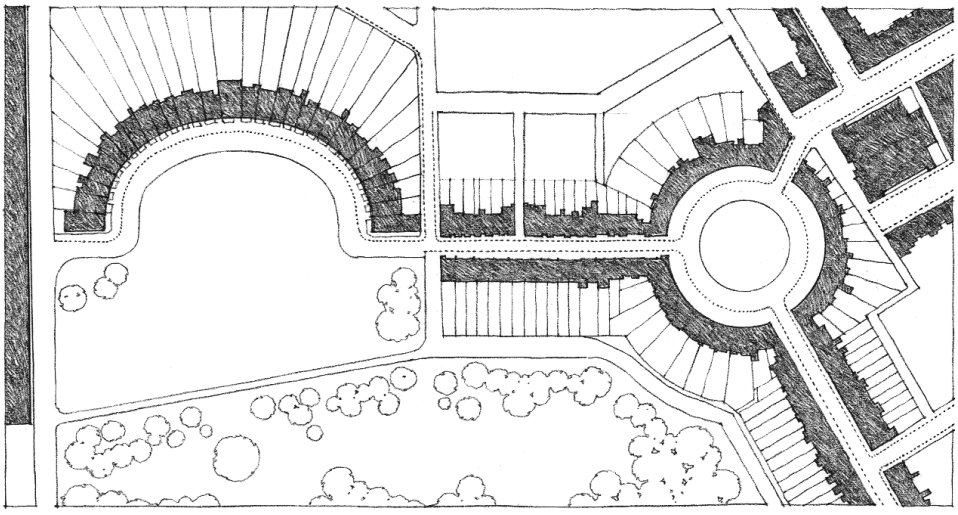


Can Lis, Porto Petro, Majorca, 1971, Jørn Utzon

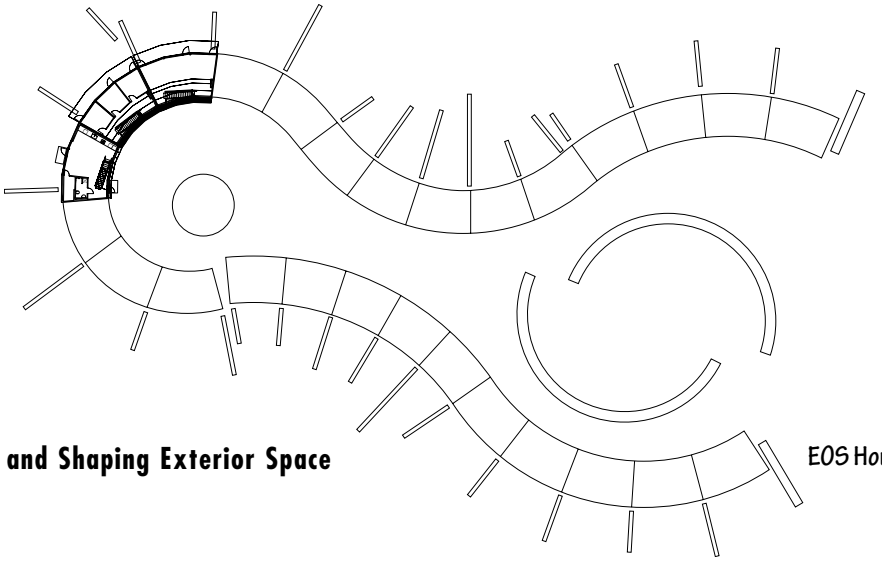
Linear Organizations Adapting to Site...



Typical Upper-Floor Plan, **Baker House**, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1948, Alvar Aalto



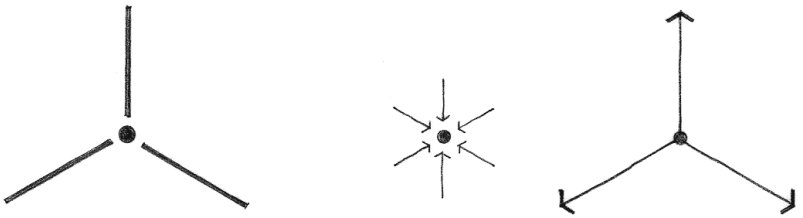
Plan for the **Circus** (1754, John Wood, Sr.) and the **Royal Crescent** (1767–1775, John Wood) at Bath, England



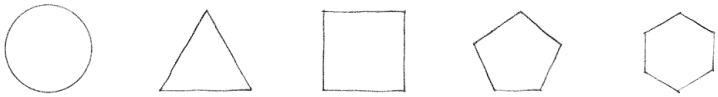
and Shaping Exterior Space

EOS Housing, Helsingborg, Sweden, 2002, Anders Wilhelmson

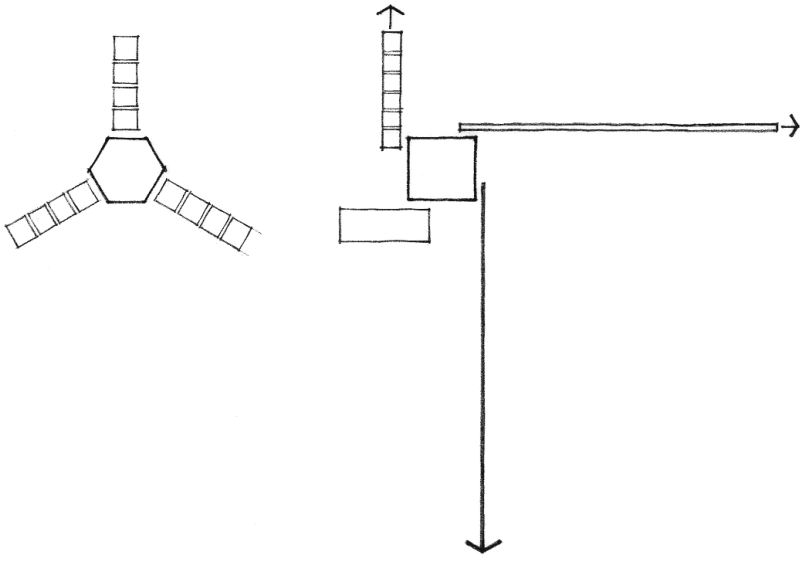
RADIAL ORGANIZATIONS



A radial organization of space combines elements of both centralized and linear organizations. It consists of a dominant central space from which a number of linear organizations extend in a radial manner. Whereas a centralized organization is an introverted scheme that focuses inward on its central space, a radial organization is an extroverted plan that reaches out to its context. With its linear arms, it can extend and attach itself to specific elements or features of its site.

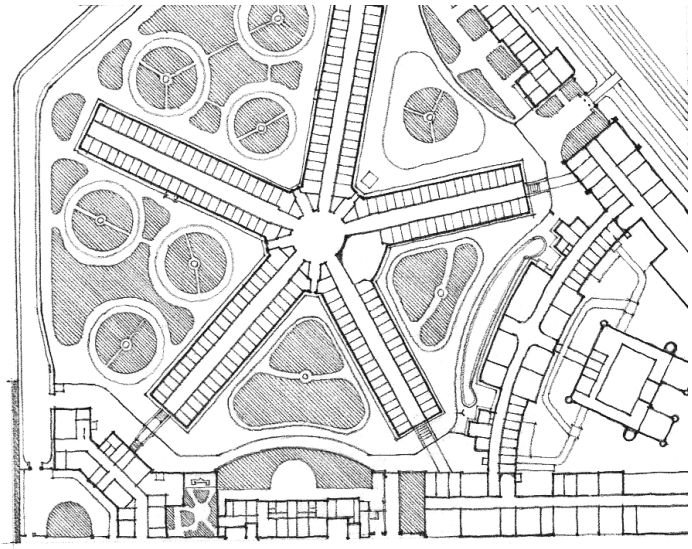


As with centralized organizations, the central space of a radial organization is generally regular in form. The linear arms, for which the central space is the hub, may be similar to one another in form and length and maintain the regularity of the organization's overall form.

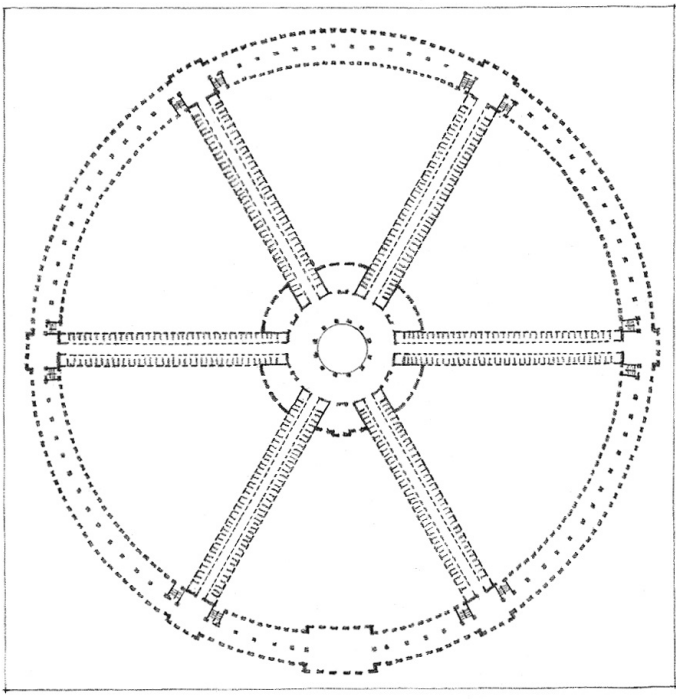


The radiating arms may also differ from one another in order to respond to individual requirements of function and context.

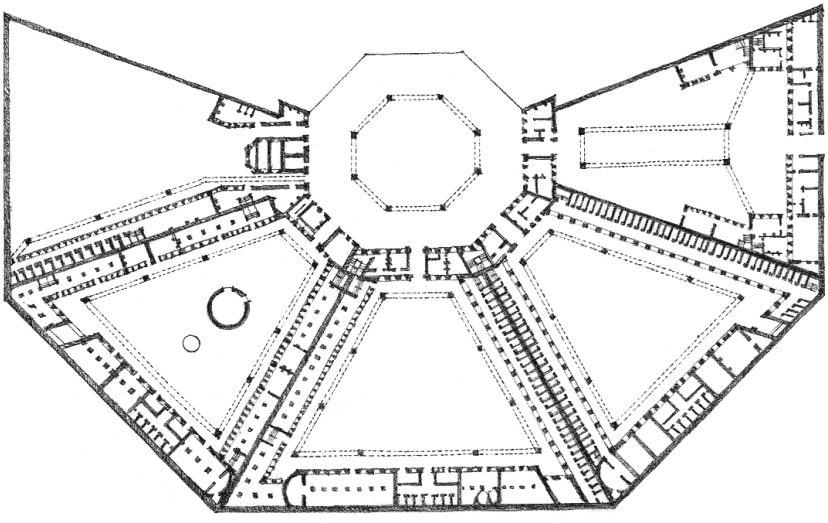
A specific variation of a radial organization is the pinwheel pattern wherein the linear arms of the organization extend from the sides of a square or rectangular central space. This arrangement results in a dynamic pattern that visually suggests a rotational movement about the central space.



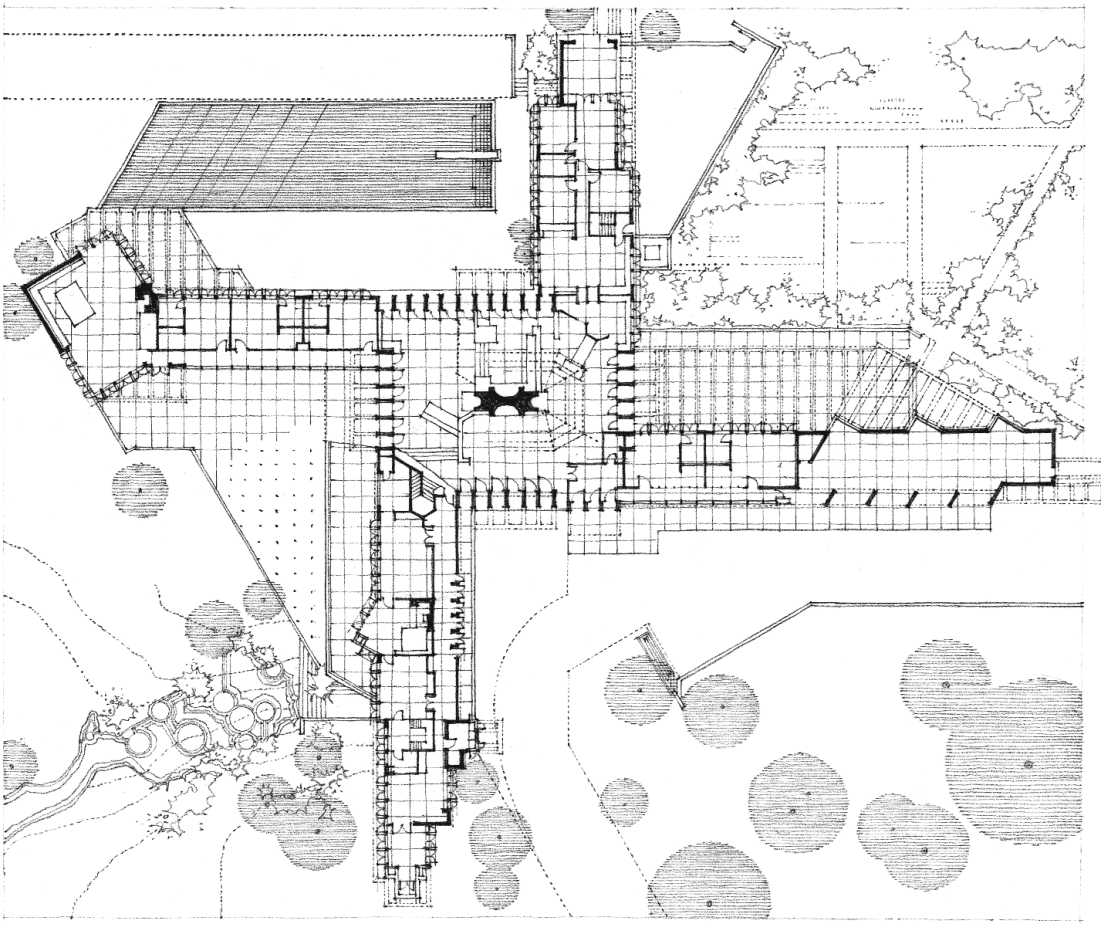
Moabit Prison, Berlin, 1869–1879, August Busse and Heinrich Herrmann



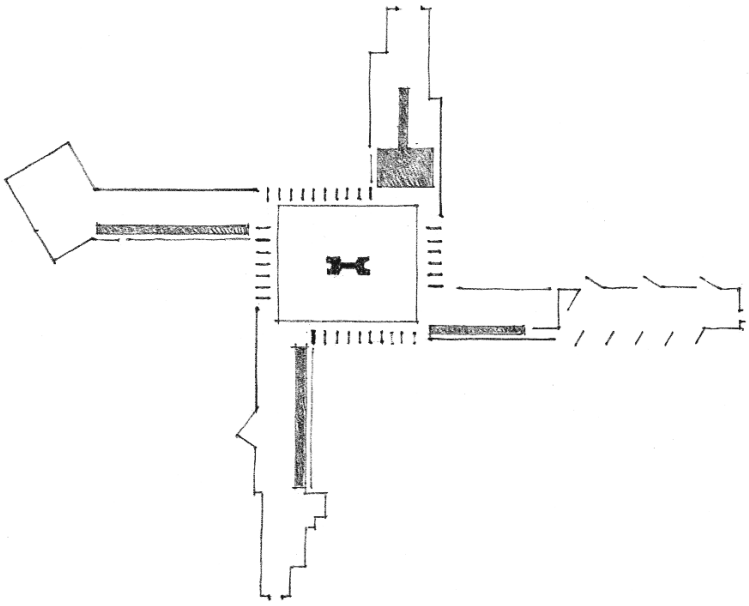
Hôtel Dieu (Hospital), 1774, Antoine Petit

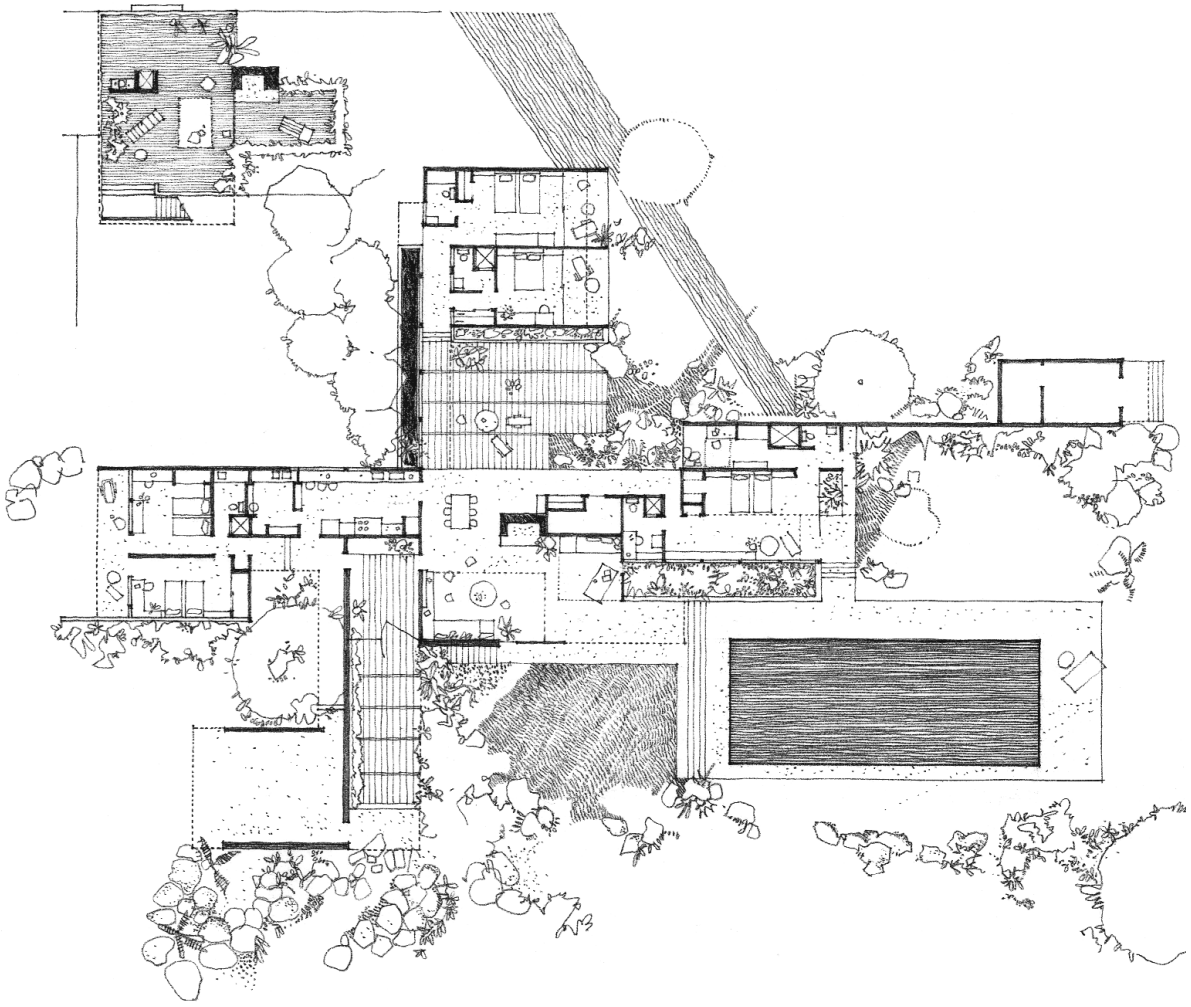


Maison de Force (Prison), Ackerghem near Ghent, Belgium, 1772–1775, Malfaison and Kluchman

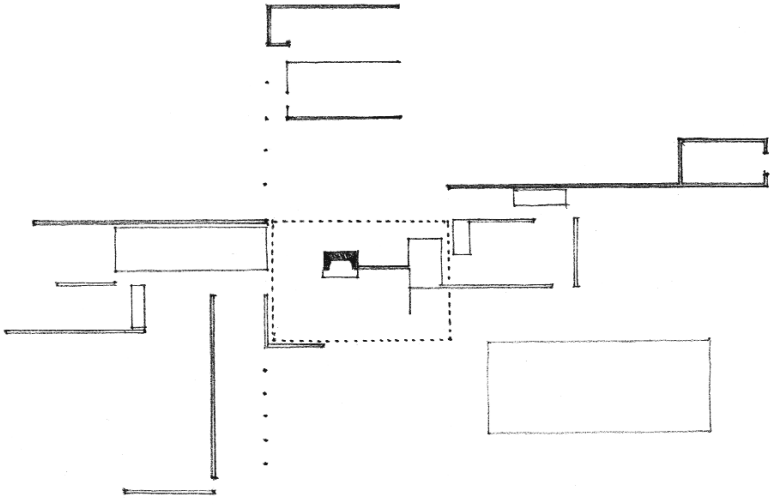


Herbert F. Johnson House (Wingspread), Wind Point, Wisconsin, 1937, Frank Lloyd Wright

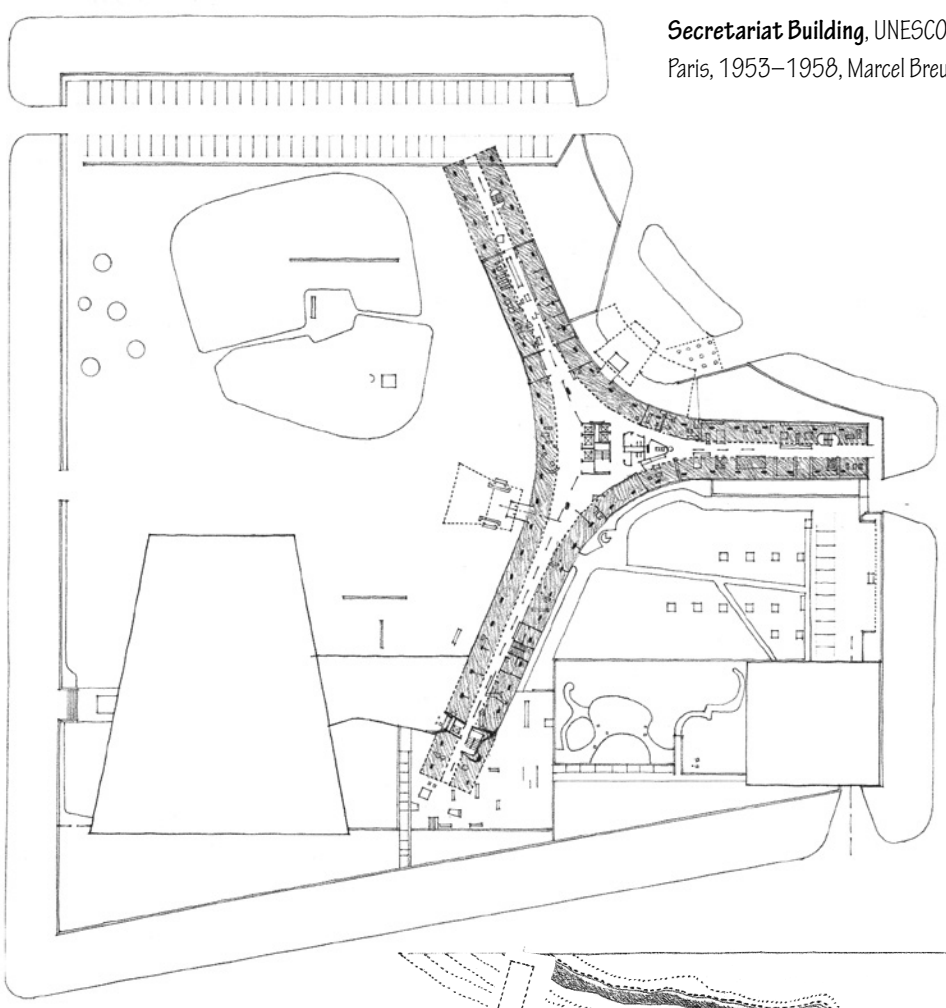




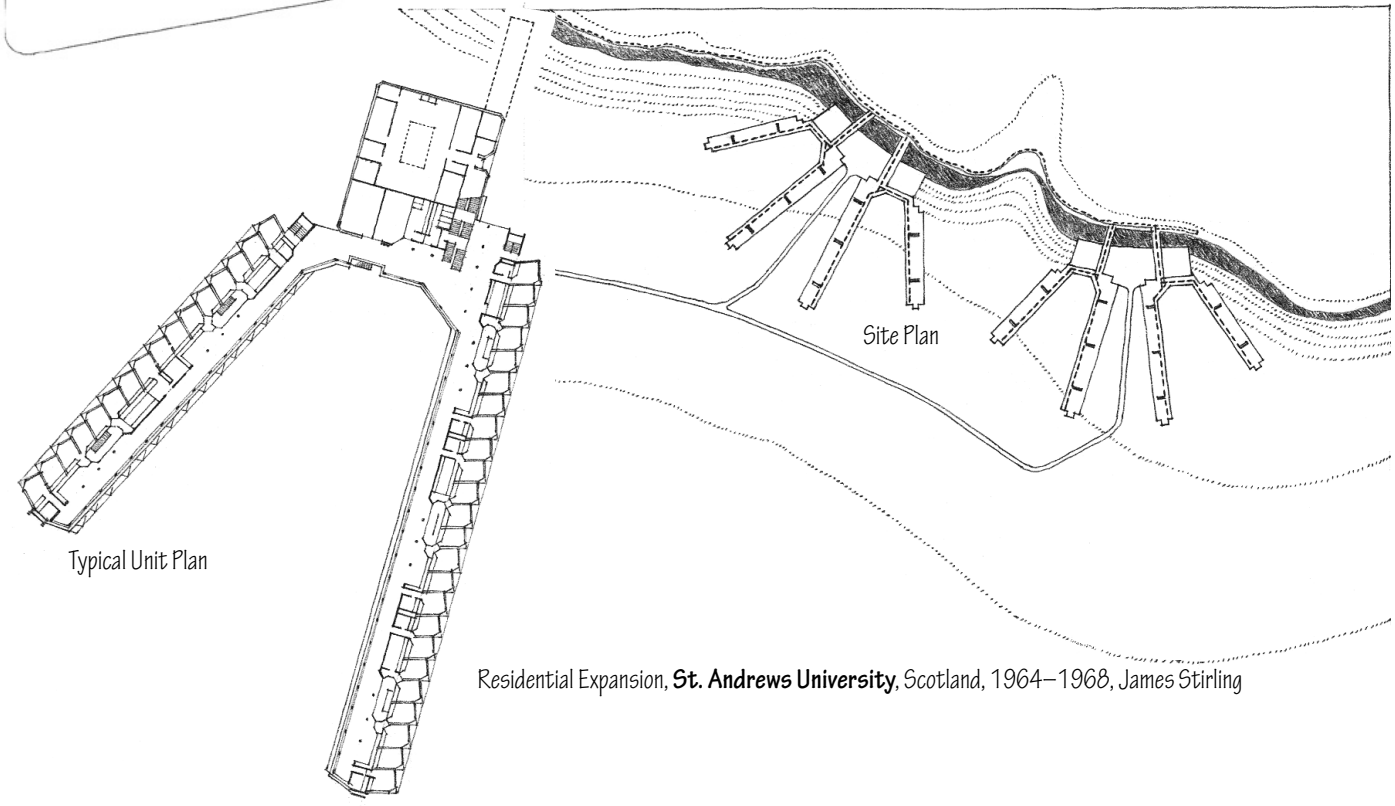
Kaufmann Desert House, Palm Springs, California, 1946, Richard Neutra



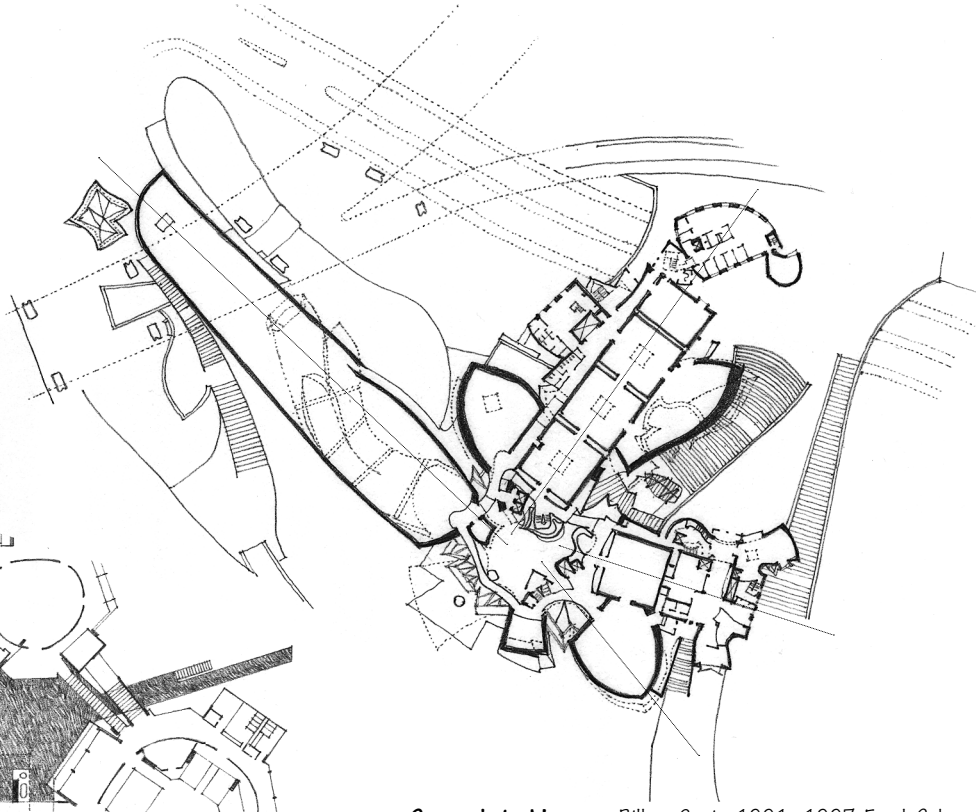
RADIAL ORGANIZATIONS



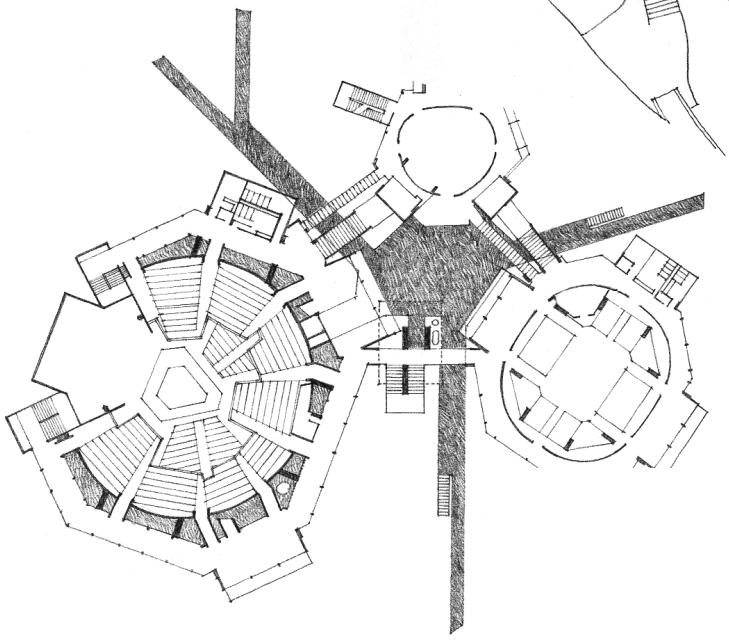
Secretariat Building, UNESCO Headquarters, Place de Fontenoy, Paris, 1953–1958, Marcel Breuer



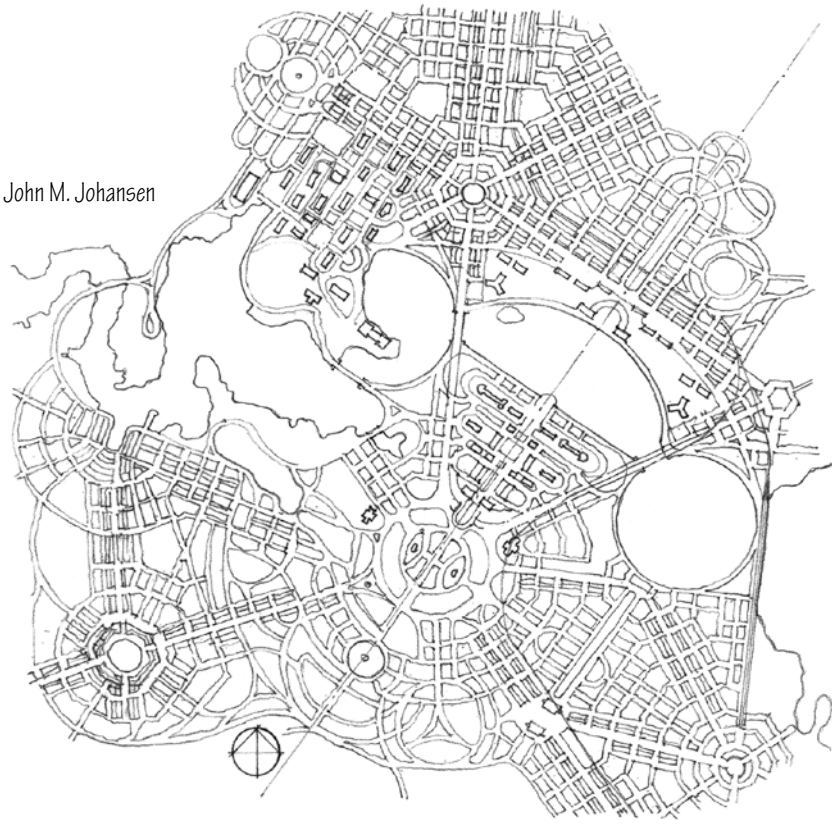
Residential Expansion, **St. Andrews University**, Scotland, 1964–1968, James Stirling



Guggenheim Museum, Bilbao, Spain, 1991–1997, Frank Gehry

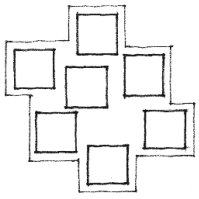


New Mummers Theater, Oklahoma City, Oklahoma, 1970, John M. Johansen

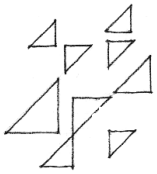


Plan for Canberra, Australia, 1911, Walter Burley Griffin

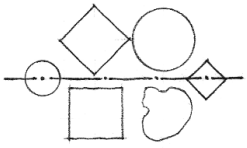
CLUSTERED ORGANIZATIONS



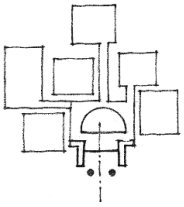
Repetitive spaces



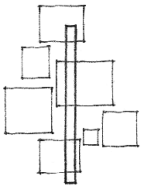
Sharing a common shape



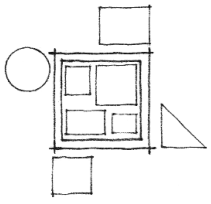
Organized by an axis



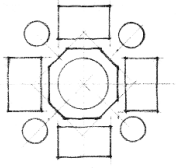
Clustered about an entry



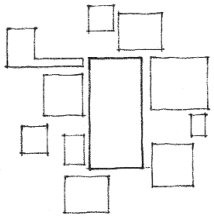
Grouped along a path



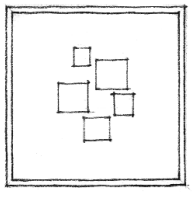
A loop path



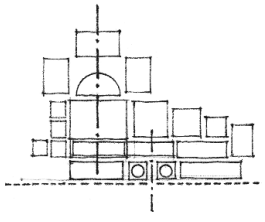
Centralized pattern



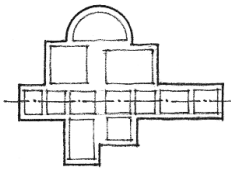
Clustered pattern



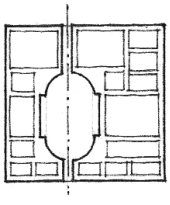
Contained within a space



Axial conditions



Axial condition



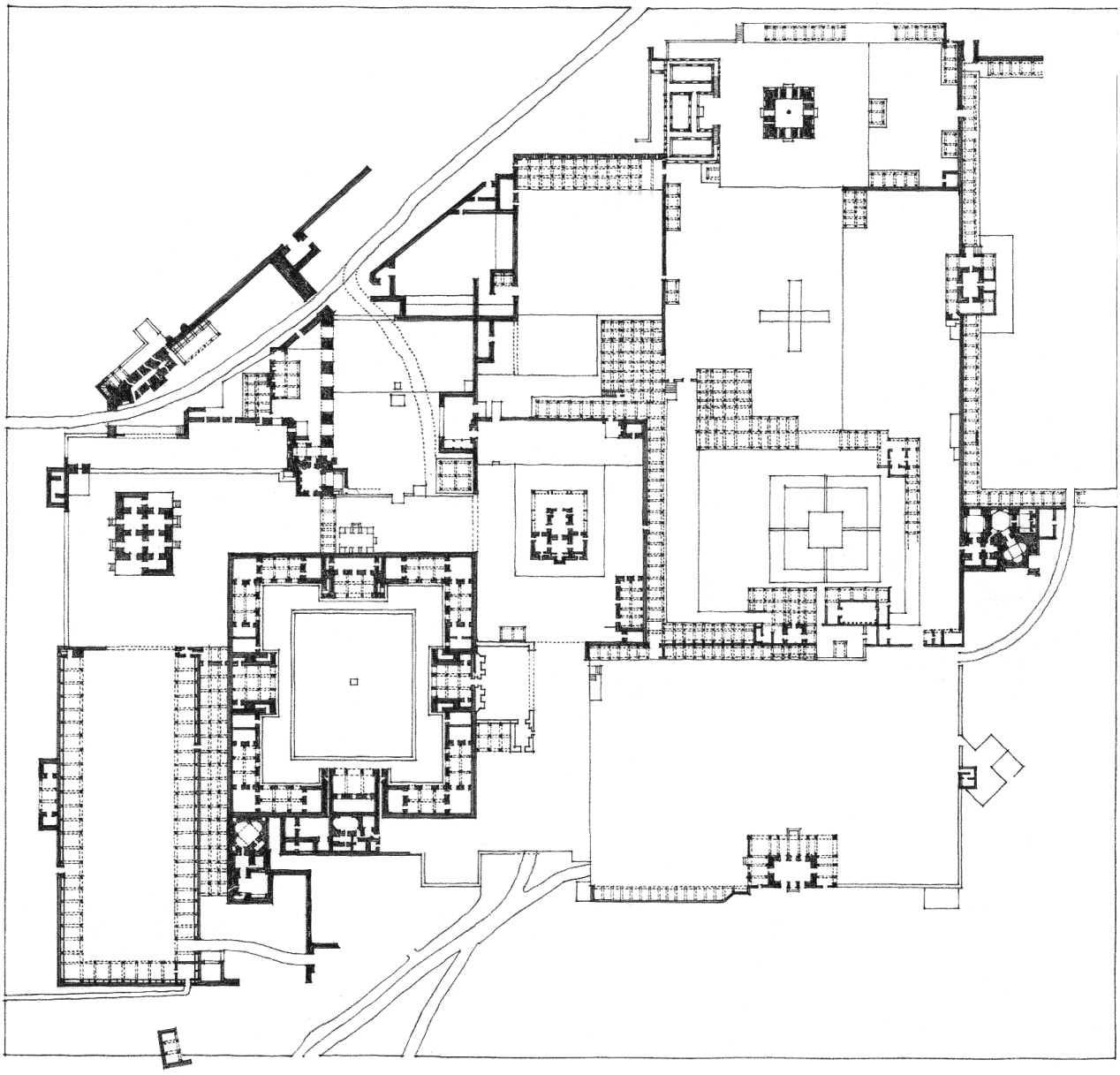
Symmetrical condition

A clustered organization relies on physical proximity to relate its spaces to one another. It often consists of repetitive, cellular spaces that have similar functions and share a common visual trait such as shape or orientation. A clustered organization can also accept within its composition spaces that are dissimilar in size, form, and function, but related to one another by proximity or a visual ordering device such as symmetry or an axis. Because its pattern does not originate from a rigid geometrical concept, the form of a clustered organization is flexible and can accept growth and change readily without affecting its character.

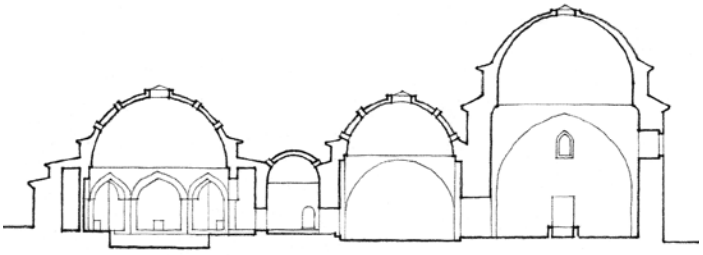
Clustered spaces can be organized about a point of entry into a building or along the path of movement through it. The spaces can also be clustered about a large defined field or volume of space. This pattern is similar to that of a centralized organization, but it lacks the latter's compactness and geometrical regularity. The spaces of a clustered organization can also be contained within a defined field or volume of space.

Since there is no inherent place of importance within the pattern of a clustered organization, the significance of a space must be articulated by its size, form, or orientation within the pattern.

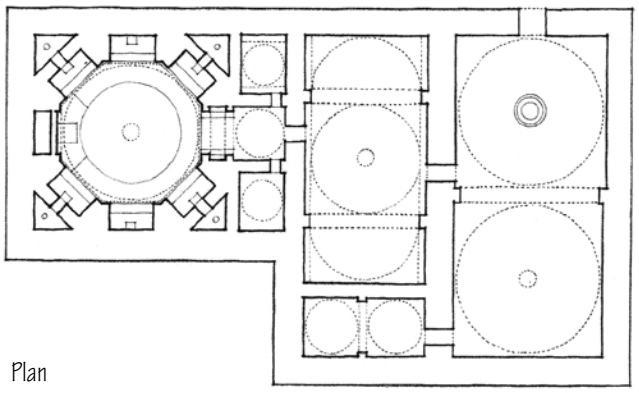
Symmetry or an axial condition can be used to strengthen and unify portions of a clustered organization and help articulate the importance of a space or group of spaces within the organization.



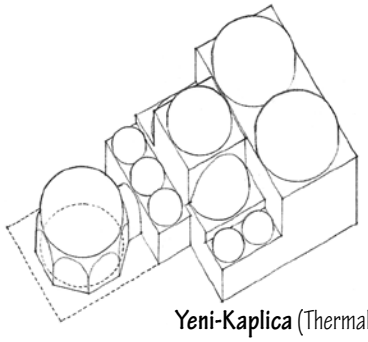
Fatehpur Sikri, *Palace Complex of Akbar the Great Mogul Emperor of India, 1569–1574*



Section



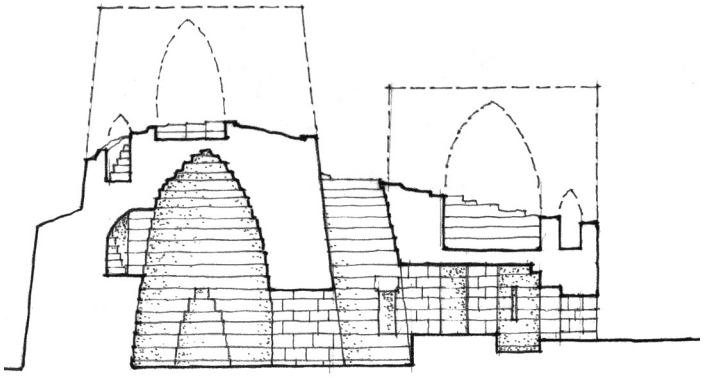
Plan

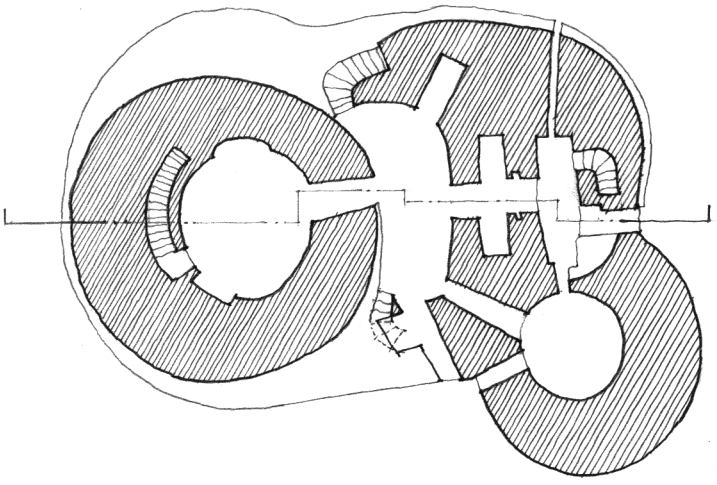


Yeni-Kaplica (Thermal Bath), Bursa,Turkey

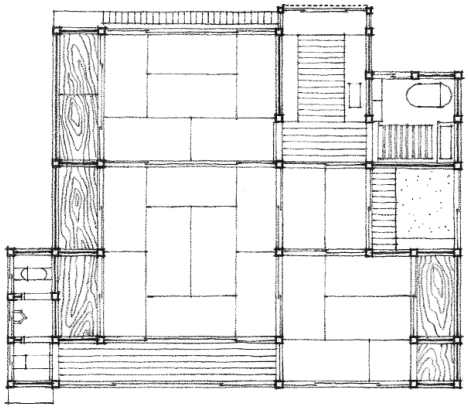
Oblique view

Spaces Organized by Geometry



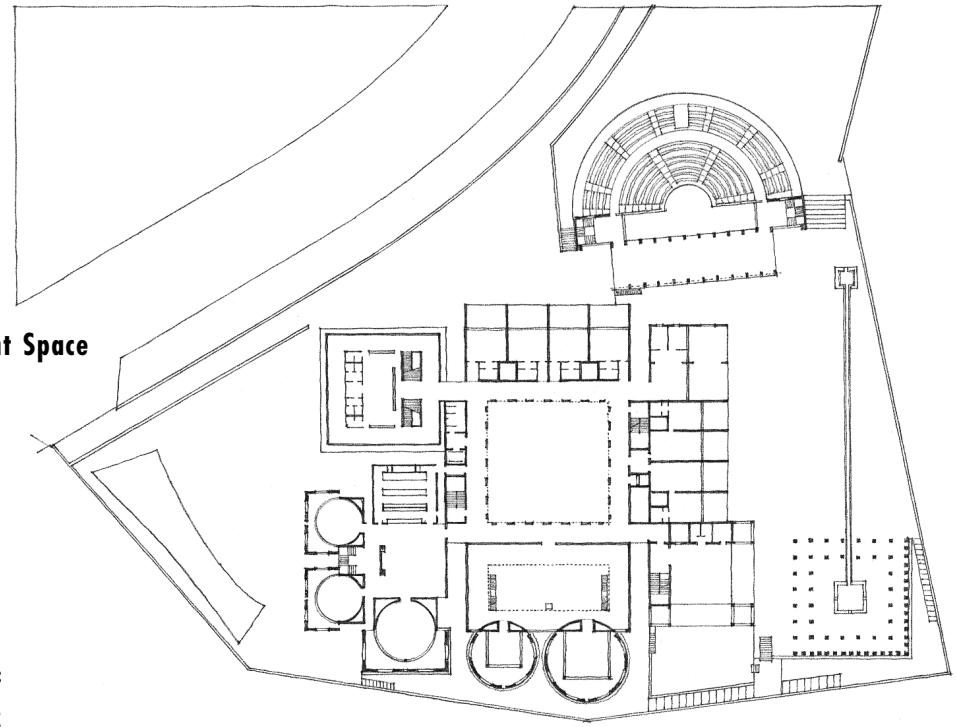


Nuraghe at Palmavera, Sardinia, typical of the ancient stone towers of the Nuraghic culture, 18th–16th century B.C.

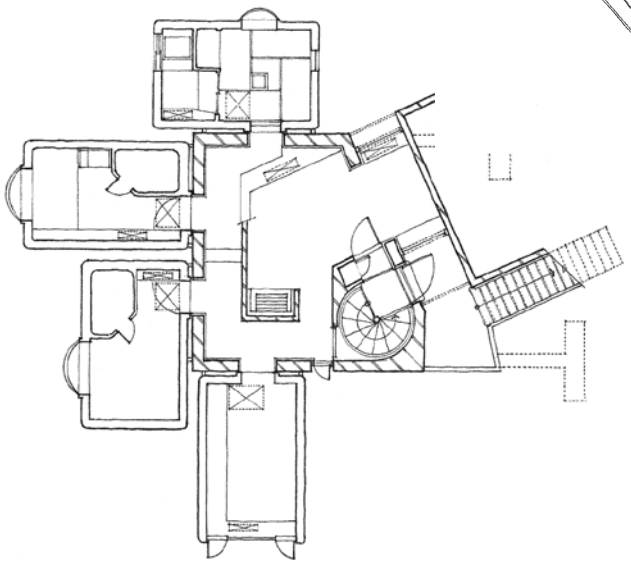


Traditional Japanese House

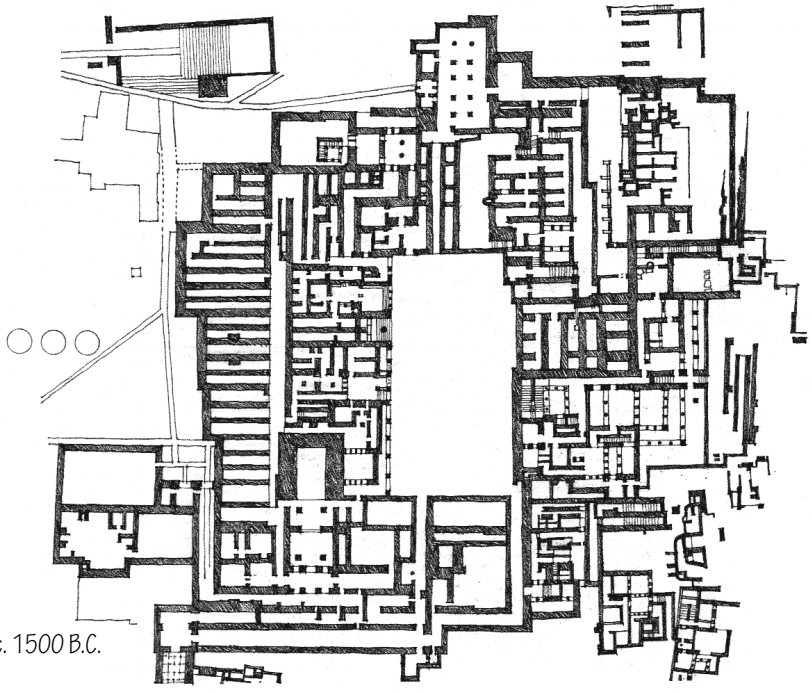
Meeting House, Salk Institute of Biological Studies (Project), La Jolla, California, 1959–1965, Louis Kahn



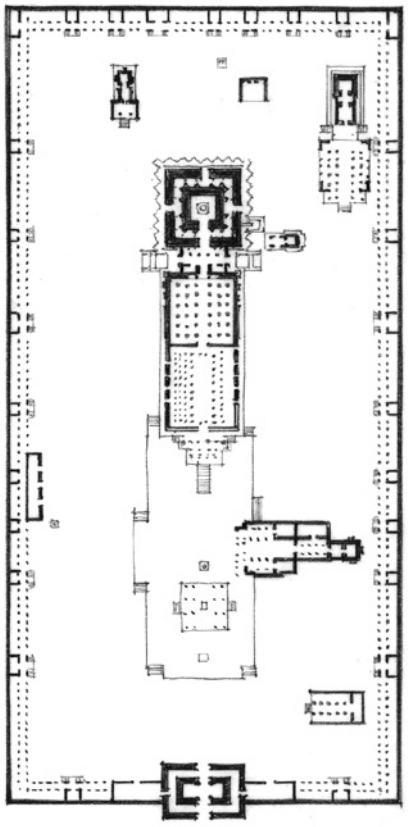
Spaces Organized Around a Dominant Space



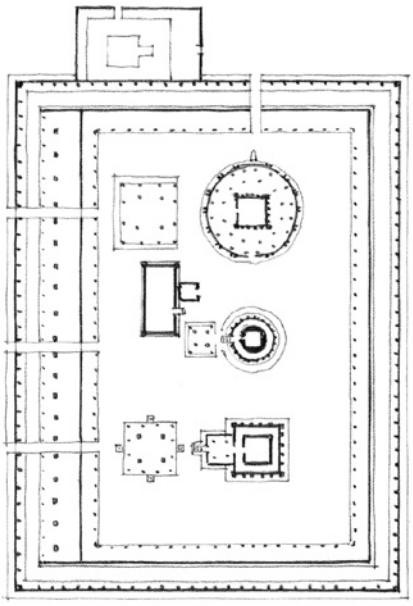
Karuizawa House, Country Retreat, 1974, Kisho Kurokawa



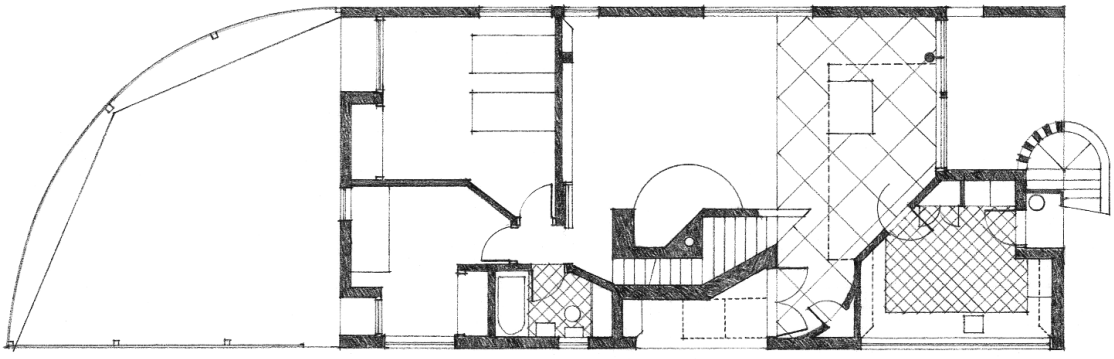
Palace of King Minos, Knossos, Crete, c. 1500 B.C.



Rajarajeshwara Temple, Thanjavur, India, 11th century

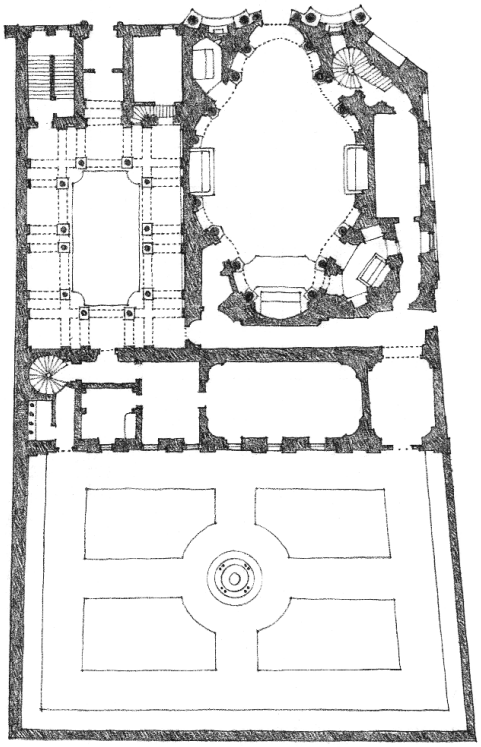


Vadakkunnathan Temple, Trichur, India, 11th century

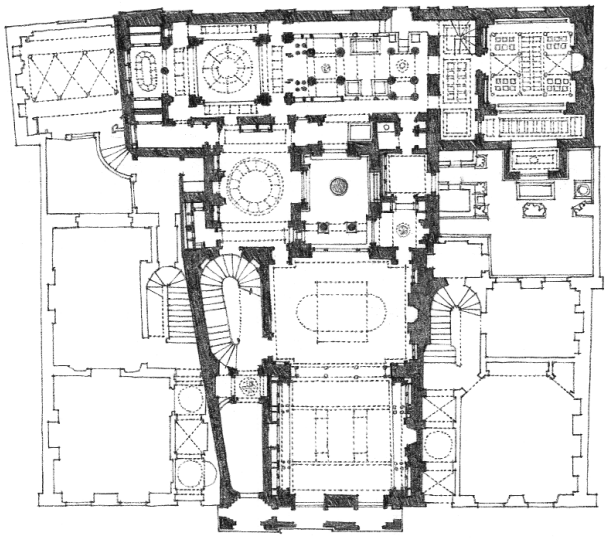


House for Mrs. Robert Venturi, Chestnut Hill, Pennsylvania, 1962–1964, Venturi and Short

Spaces Organized within a Spatial Field



St. Carlo alle Quattro Fontane, Rome, 1633–1641, Francesco Borromini

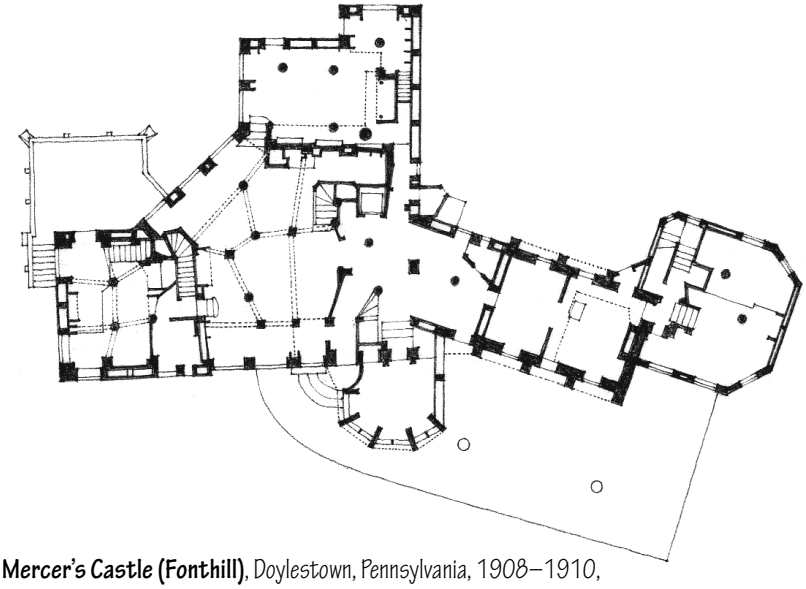


Soane House, London, England, 1812–1834, Sir John Soane

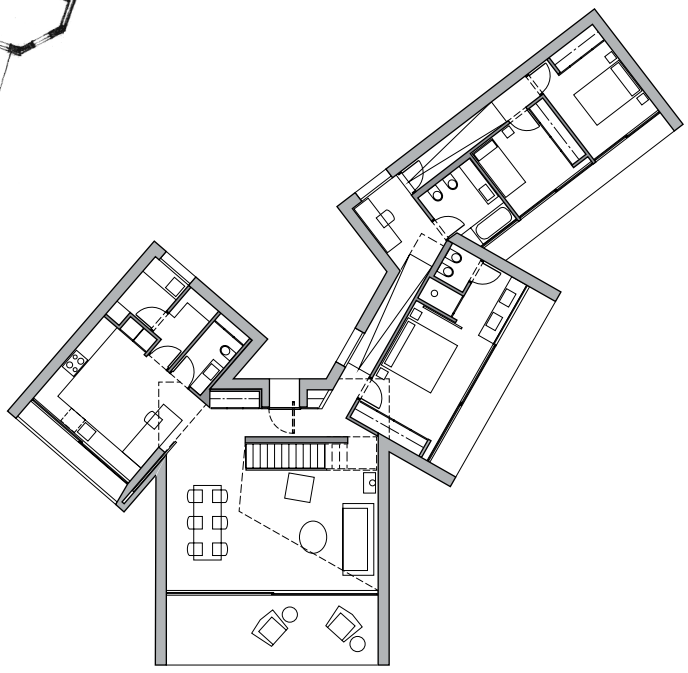
Bank of England, London, England, 1788–1833, Sir John Soane

Spaces Organized by Axial Symmetries

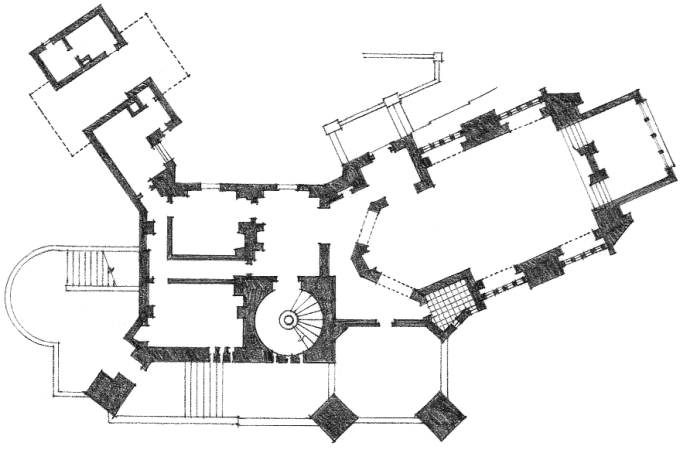
CLUSTERED ORGANIZATIONS



Mercer's Castle (Fonthill), Doylestown, Pennsylvania, 1908–1910, Henry Mercer

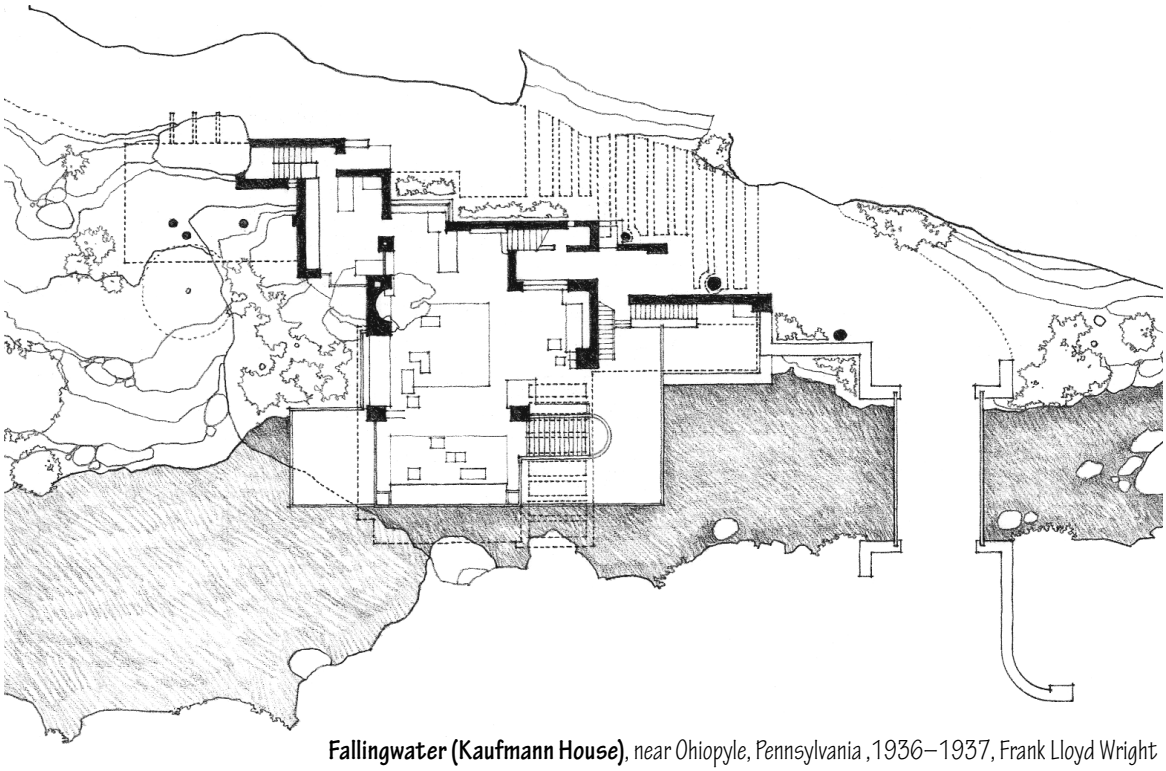


House MM, Palma de Mallorca, Spain, 2016, OHLAB / Oliver Hernaiz Architecture Lab

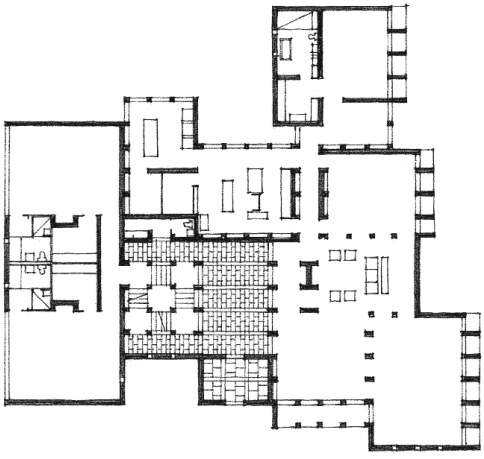


Wyntoon, Country Estate for the Hearst Family in Northern California, 1903, Bernard Maybeck

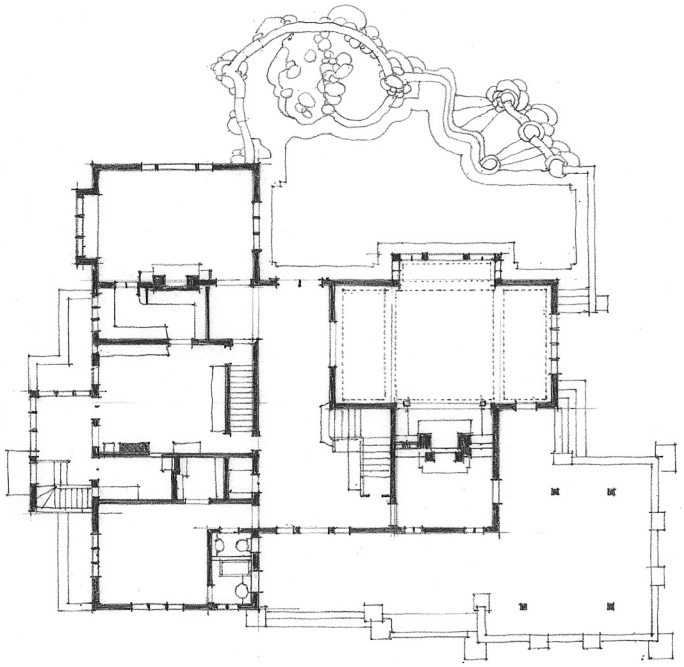
Spaces Organized by Site Conditions



Fallingwater (Kaufmann House), near Ohiopyle, Pennsylvania, 1936–1937, Frank Lloyd Wright

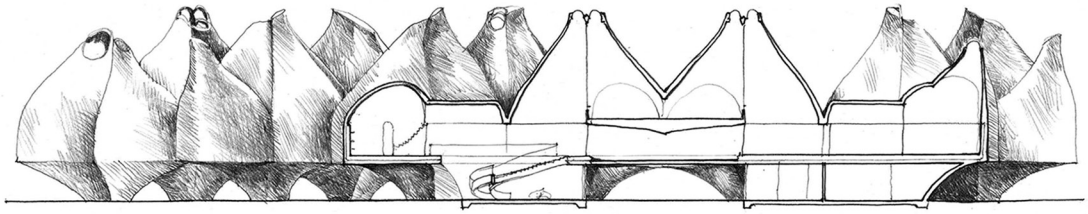


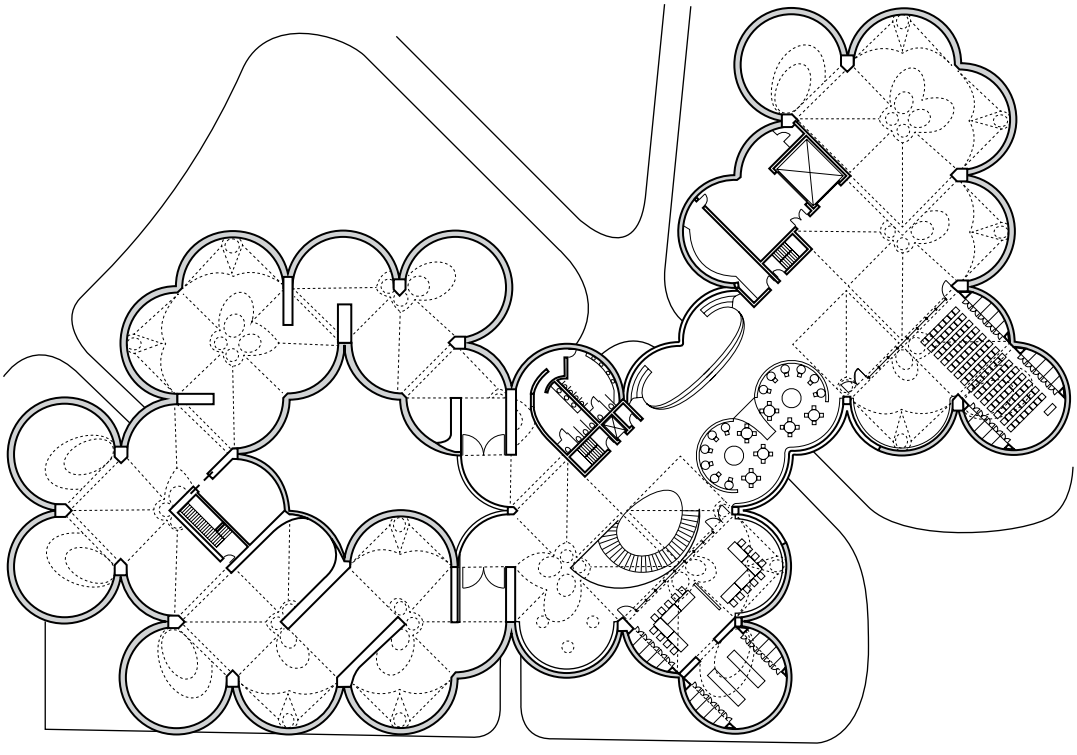
Morris House (Project), Mount Kisco, New York, 1958, Louis Kahn



***Gamble* House**, Pasadena, California, 1908, Greene & Greene

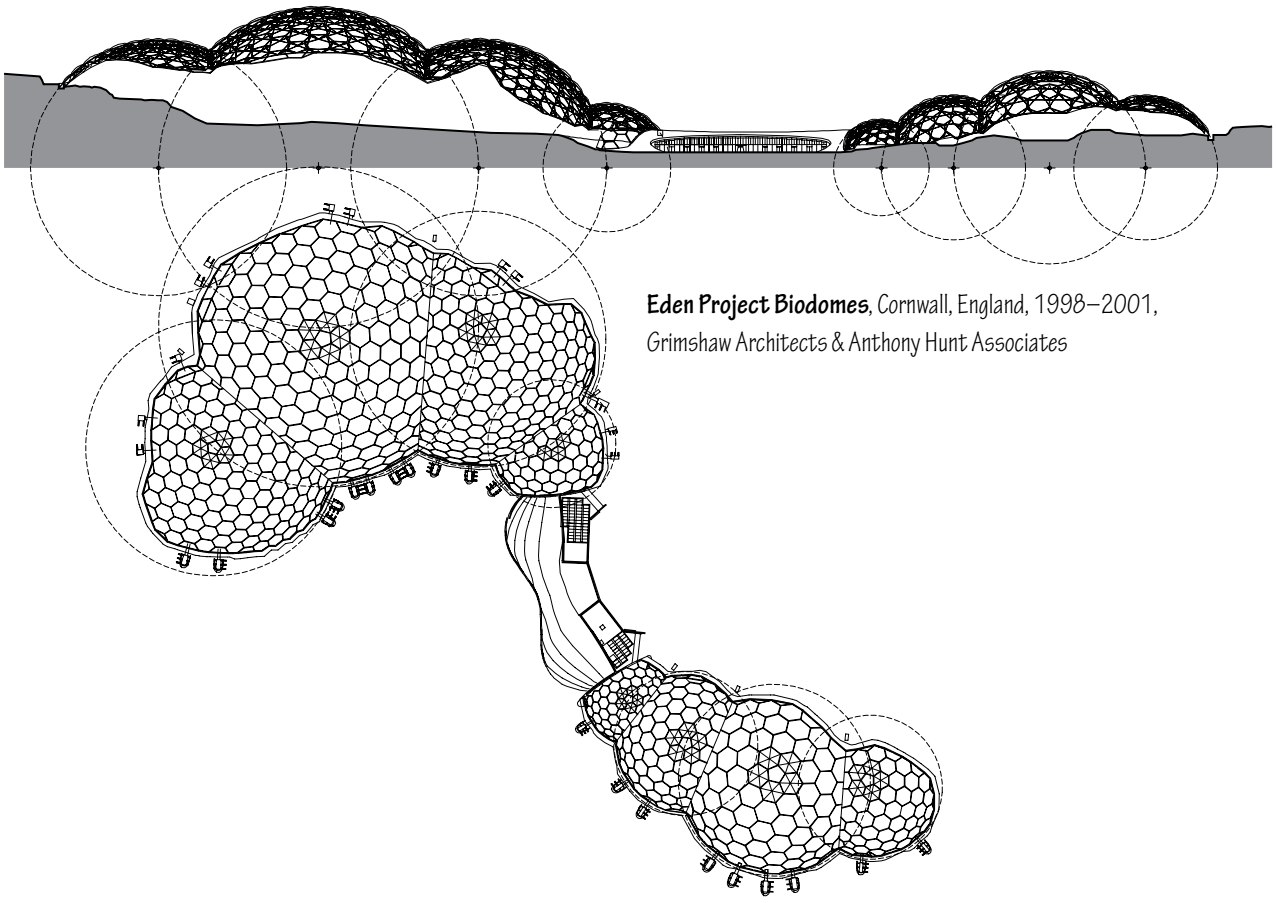
Spaces Organized by Geometric Pattern



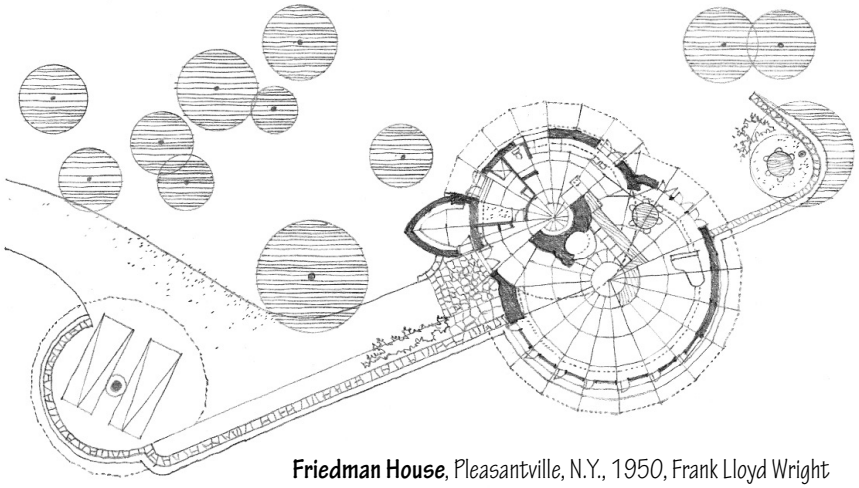


Bauhaus Museum Competiton Co-Winning Entry, 2015, Young & Ayata (Landscape Architecture: Misako Murata)

Spaces Organized by Geometric Pattern

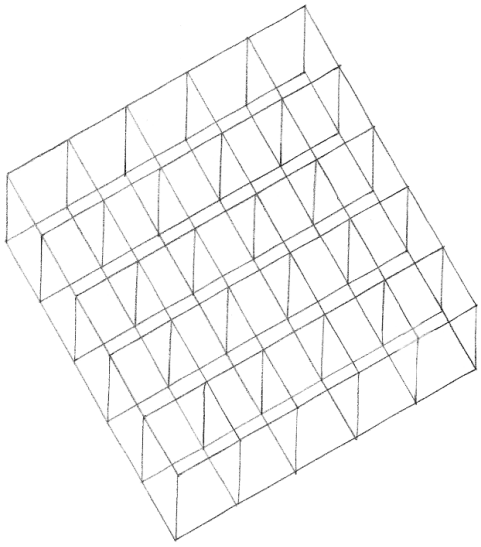


Eden Project Biodomes, Cornwall, England, 1998–2001, Grimshaw Architects & Anthony Hunt Associates

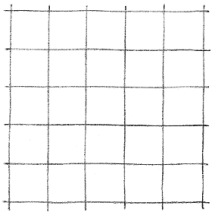


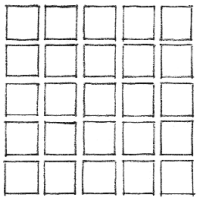
Friedman House, Pleasantville, N.Y., 1950, Frank Lloyd Wright

GRID ORGANIZATIONS

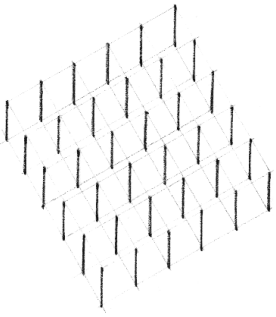


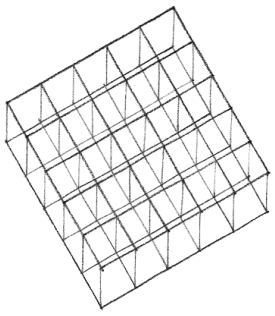
A grid organization consists of forms and spaces whose positions in space and relationships with one another are regulated by a three-dimensional grid pattern or field.

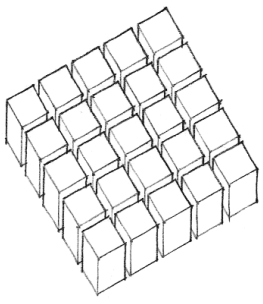




A grid is created by two, usually perpendicular, sets of parallel lines that establish a regular pattern of points at their intersections. Projected into the third dimension, the grid pattern is transformed into a set of repetitive, modular units of space.



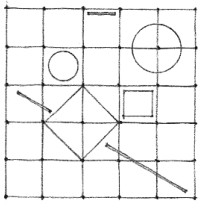


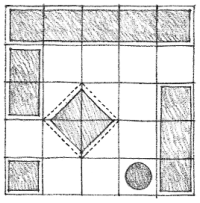


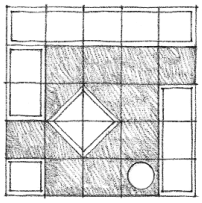
The organizing power of a grid results from the regularity and continuity of its pattern that pervades the elements it organizes. Its pattern establishes a stable set or field of reference points and lines in space with which the spaces of a grid organization, although dissimilar in size, form, or function, can share a common relationship.

GRID ORGANIZATIONS

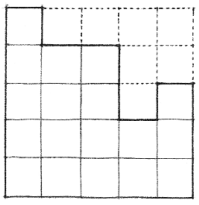
A grid is established in architecture most often by a skeletal structural system of columns and beams. Within the field of this grid, spaces can occur as isolated events or as repetitions of the grid module. Regardless of their disposition within the field, these spaces, if seen as positive forms, will create a second set of negative spaces.

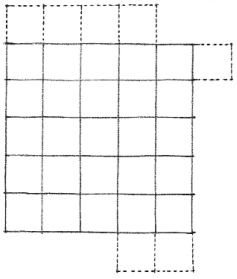


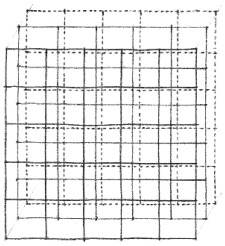




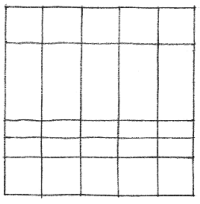
Since a three-dimensional grid consists of repetitive, modular units of space, it can be subtracted from, added to, or layered, and still maintain its identity as a grid with the ability to organize spaces. These formal manipulations can be used to adapt a grid form to its site, to define an entrance or outdoor space, or to allow for its growth and expansion.

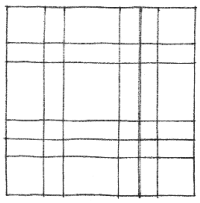


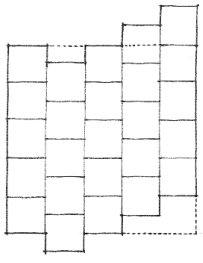




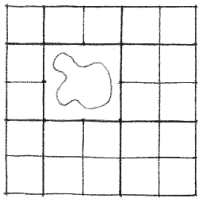
To accommodate the specific dimensional requirements of its spaces or to articulate zones of space for circulation or service, a grid can be made irregular in one or two directions. This dimensional transformation would create a hierarchical set of modules differentiated by size, proportion, and location.

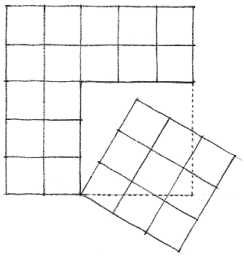


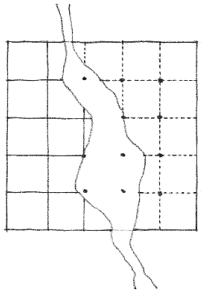




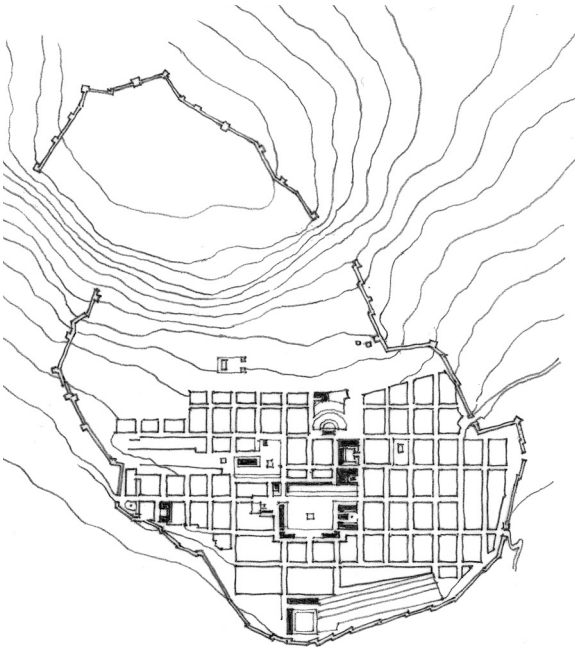
A grid can also undergo other transformations. Portions of the grid can slide to alter the visual and spatial continuity across its field. A grid pattern can be interrupted to define a major space or accommodate a natural feature of its site. A portion of the grid can be dislocated and rotated about a point in the basic pattern. Across its field, a grid can transform its image from a pattern of points to lines, to planes, and finally, to volumes.



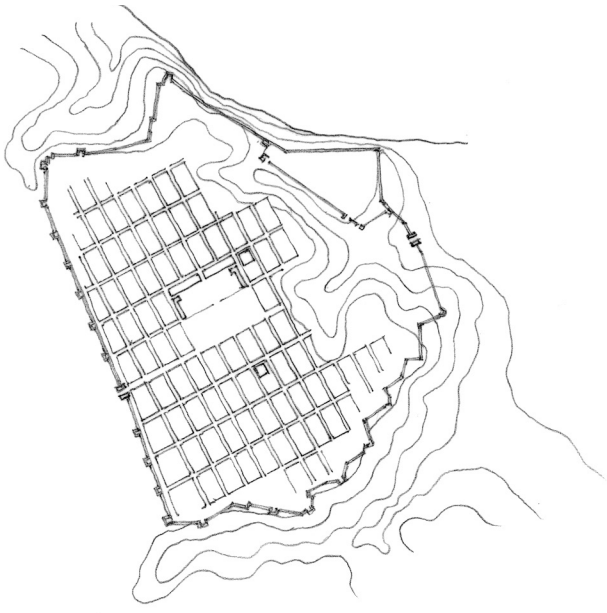




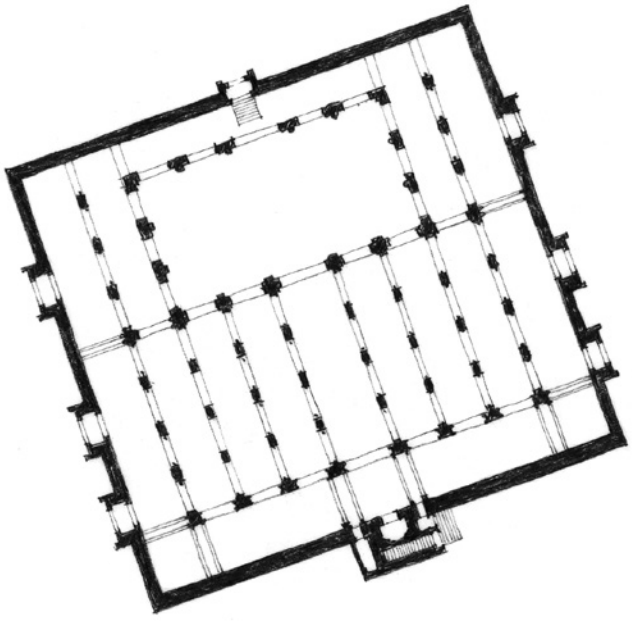
GRID ORGANIZATIONS



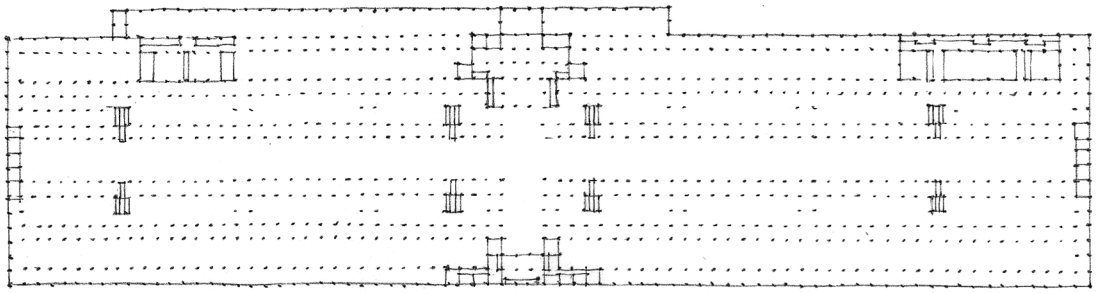
City of **Priene**, Turkey, founded 334 B.C.



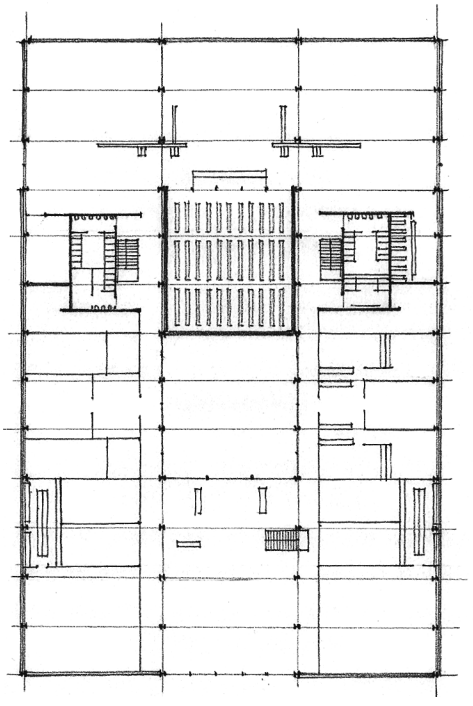
Plan of **Dura-Europos**, near Salhiyé, Syria, 4th century B.C.



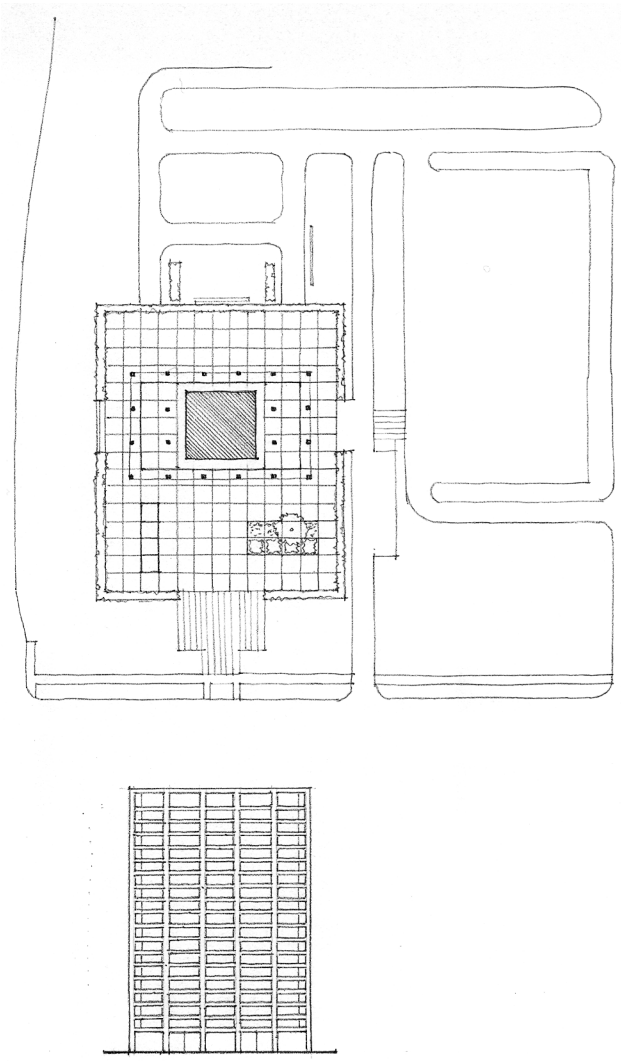
Mosque of Tinmal, Morocco, 1153–1154



Crystal Palace, London, England, Great Exhibition of 1851, Sir Joseph Paxton

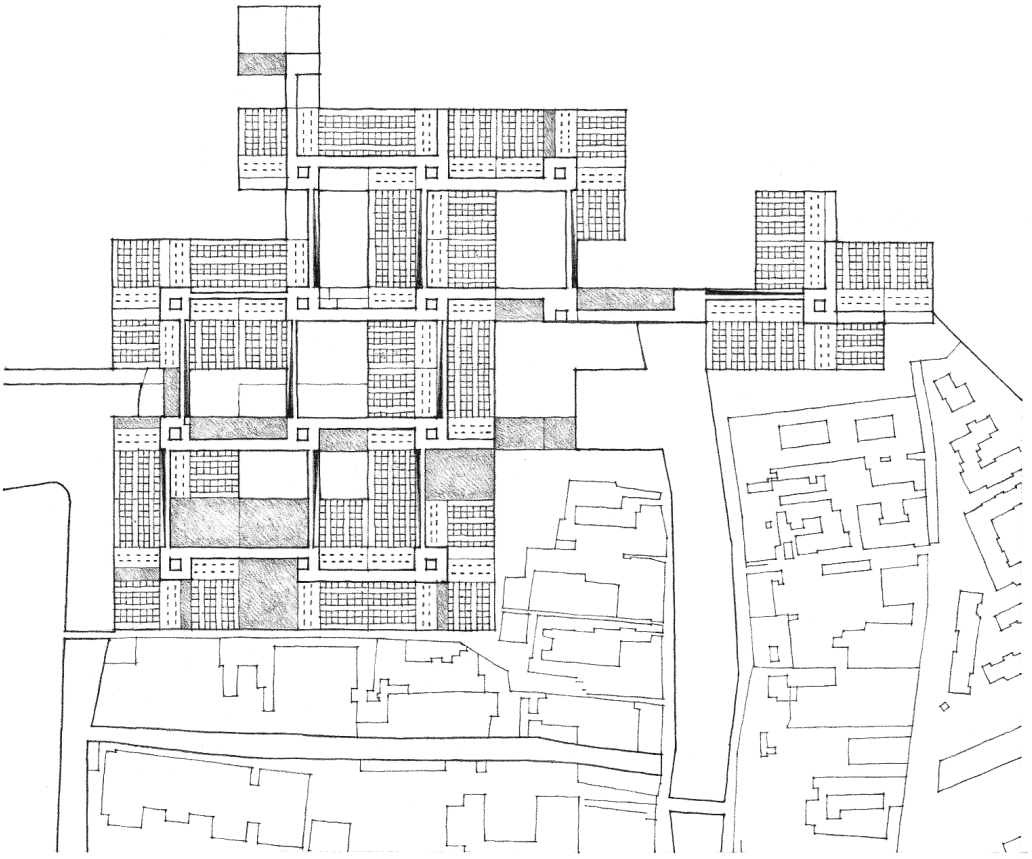


IIT Library Building (Project), Chicago, Illinois, 1942–1943, Mies van der Rohe

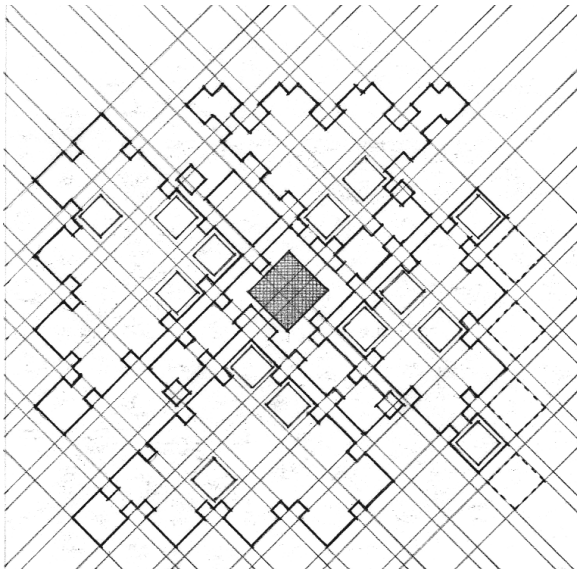


Business Men's Assurance Co. of America, Kansas City, Missouri, 1963, SOM

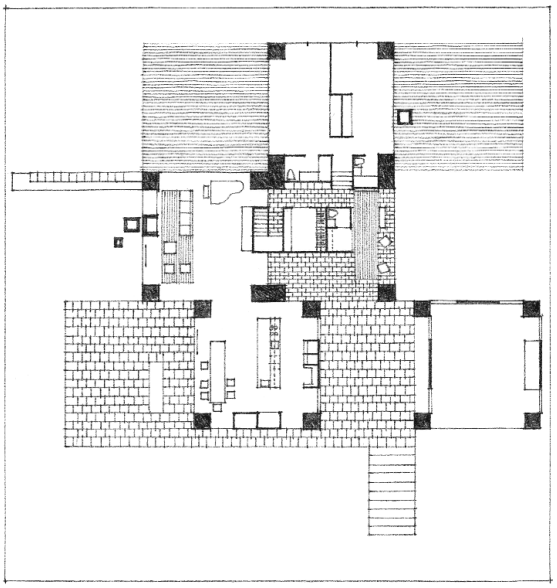
GRID ORGANIZATIONS



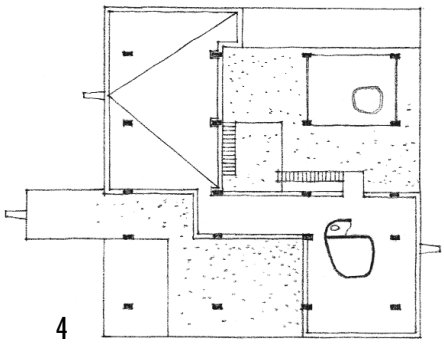
Hospital Project, Venice, 1964–1966, Le Corbusier

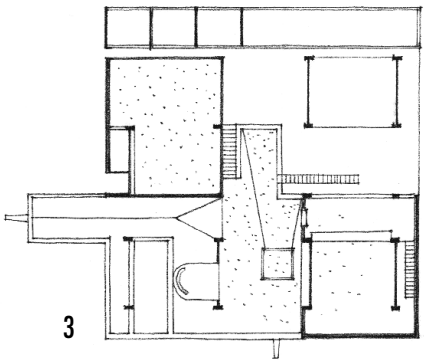


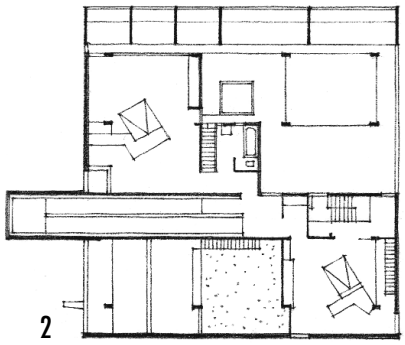
Centraal Beheer Insurance Offices, Apeldoorn, Netherlands, 1967–1972, Herman Hertzberger

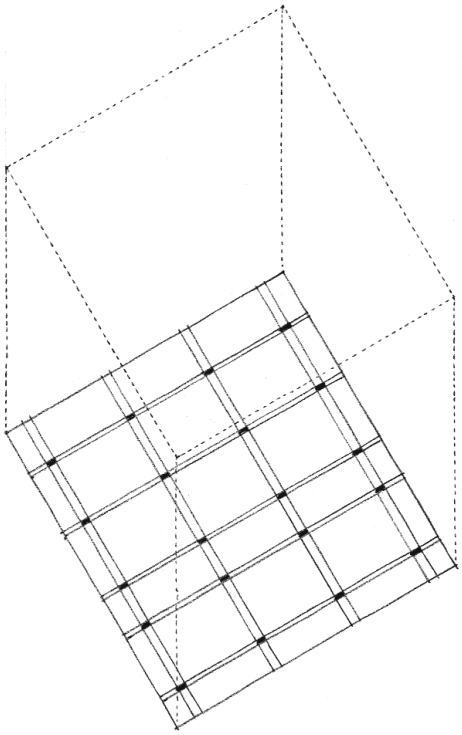


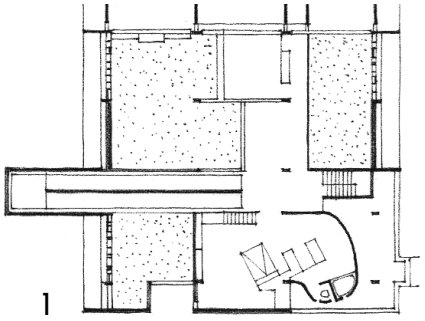
Adler House (Project), Philadelphia, Pennsylvania, 1954, Louis Kahn

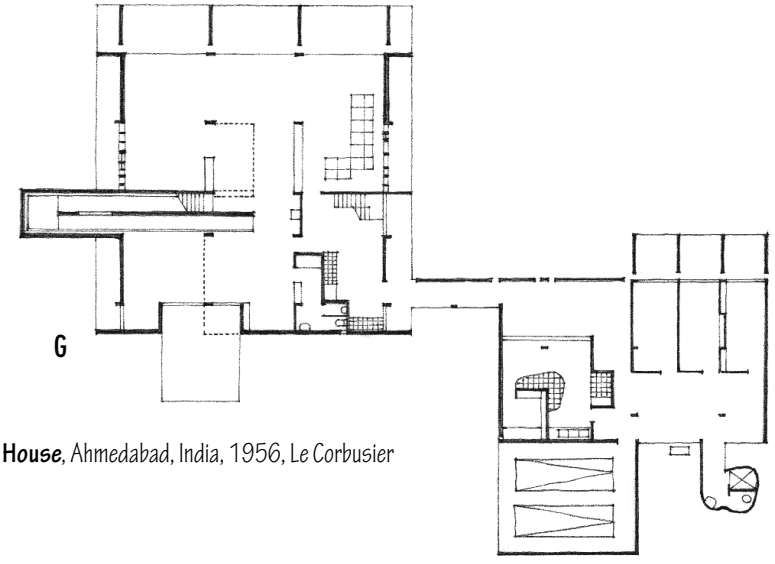




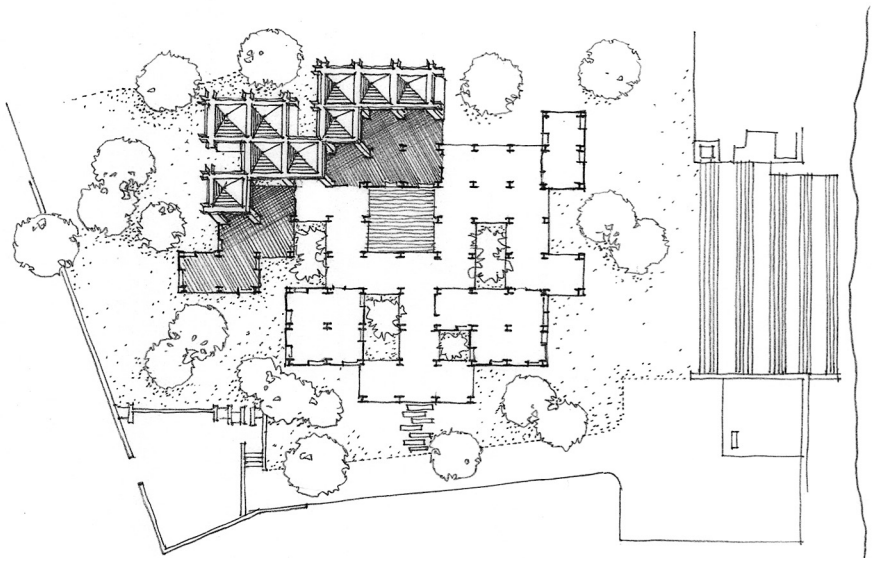




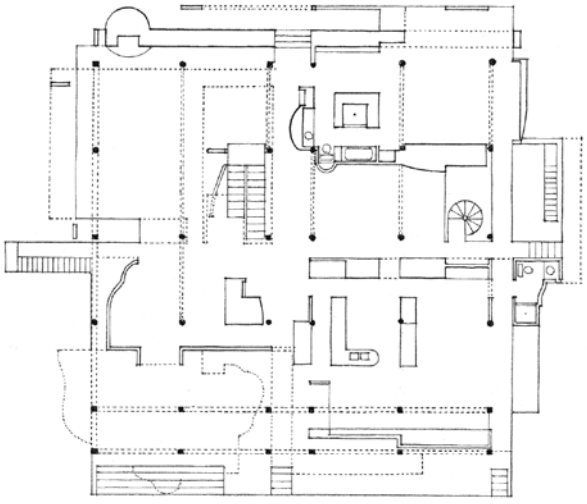




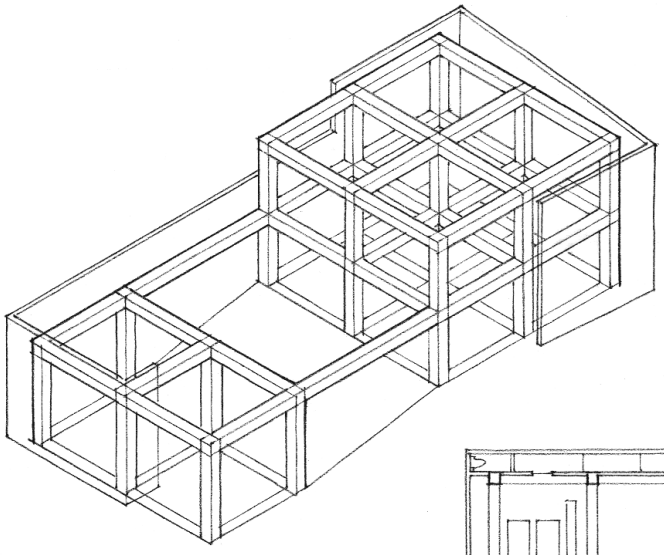
Shodhan House, Ahmedabad, India, 1956, Le Corbusier

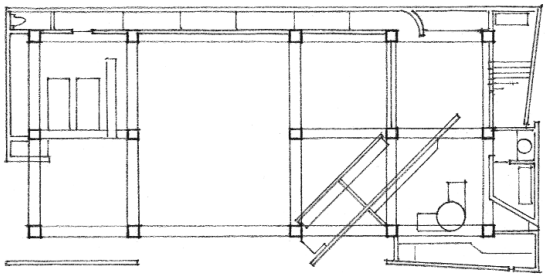


Gandhi Ashram Museum, Ahmedabad, India, 1958–1963, Charles Correa

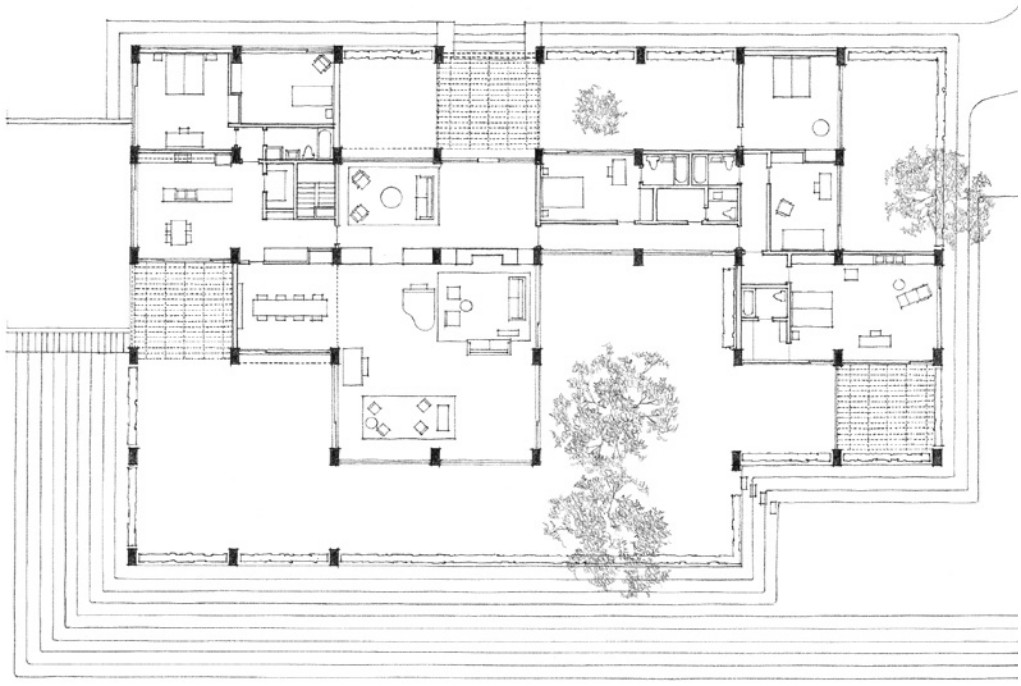


Snyderman House, Fort Wayne, Indiana, 1972, Michael Graves

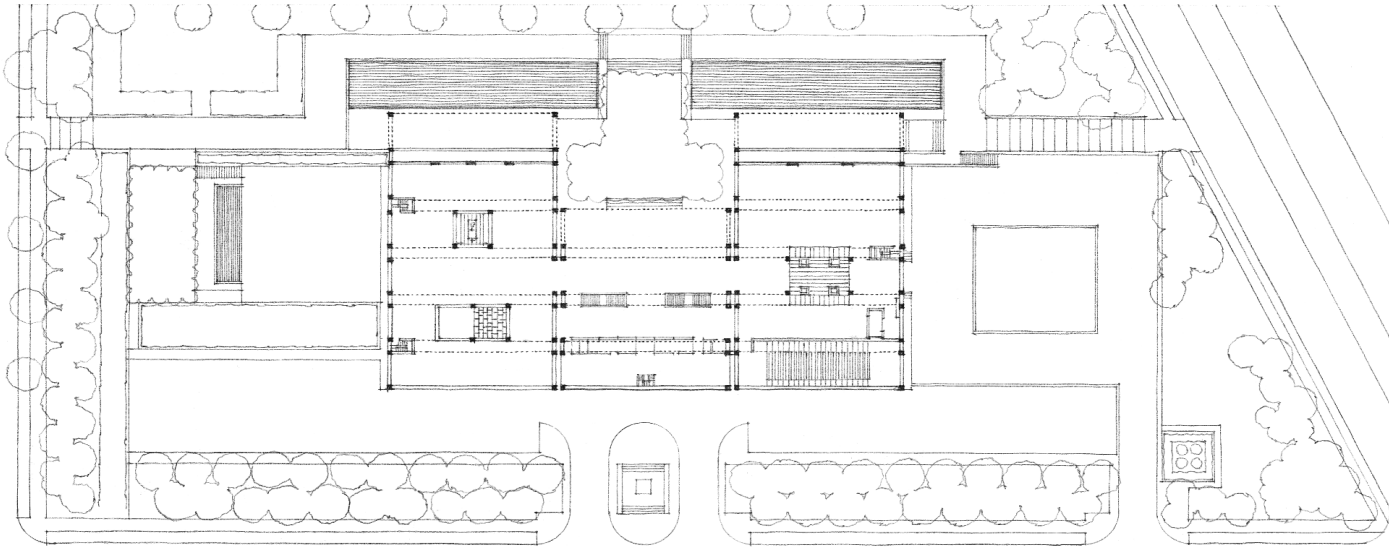




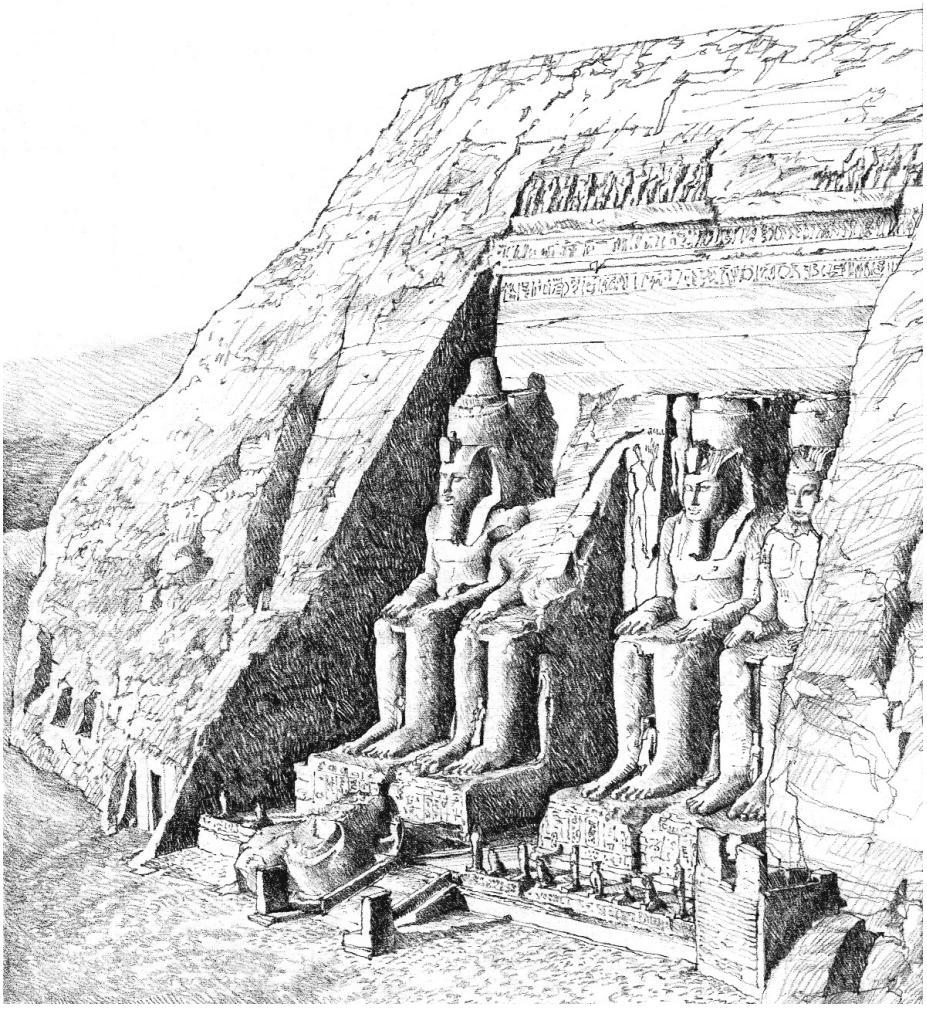
Manabe Residence, Tezukayama, Osaka, Japan, 1976–1977, Tadao Ando

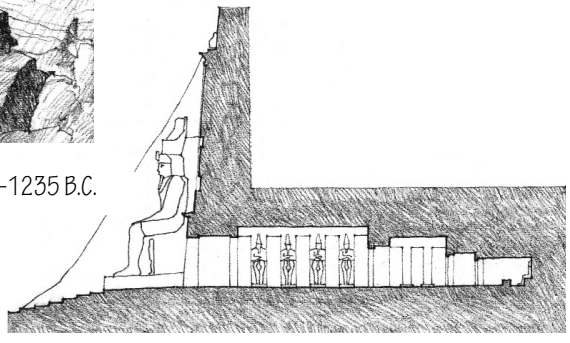


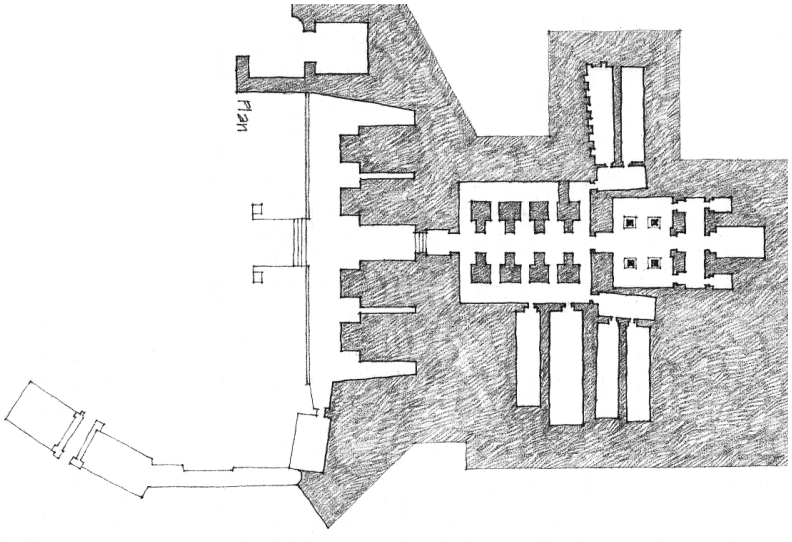
Eric Boissonas House I, New Canaan, Connecticut, 1956, Philip Johnson



Kimball Art Museum, Fort Worth, Texas, 1967–1972, Louis Kahn







Abu Simbel, *Great Temple of Rameses II, 1301–1235 B.C.*

5
Circulation

"... we have been observing that the human body, which is our most fundamental three-dimensional possession, has not itself been a central concern in the understanding of architectural form; that architecture, to the extent that it is considered an art, is characterized in its design stages as an abstract visual art and not as a body-centered art ... We believe that the most essential and memorable sense of three-dimensionality originates in the body experience and that this sense may constitute a basis for understanding spatial feeling in our experience of buildings.

...The interplay between the world of our bodies and the world of our dwelling places is always in flux. We make places that are an expression of our haptic experiences even as these experiences are generated by the places we have already created. Whether we are conscious or innocent of this process, our bodies and our movement are in constant dialogue with our buildings."

Charles Moore and Robert Yudell
Body, Memory, and Architecture
1977

Architecture: Form, Space, & Order, Fifth Edition. Francis D. K. Ching.
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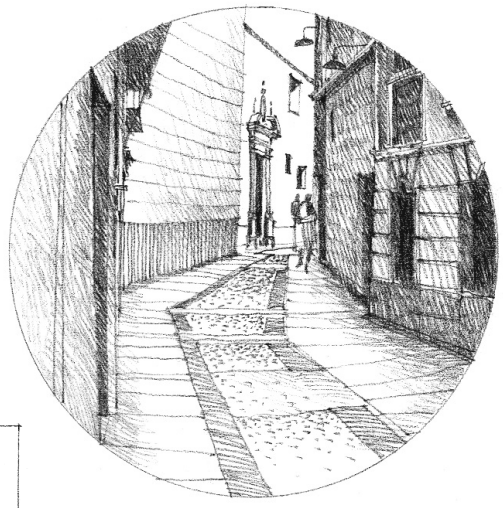
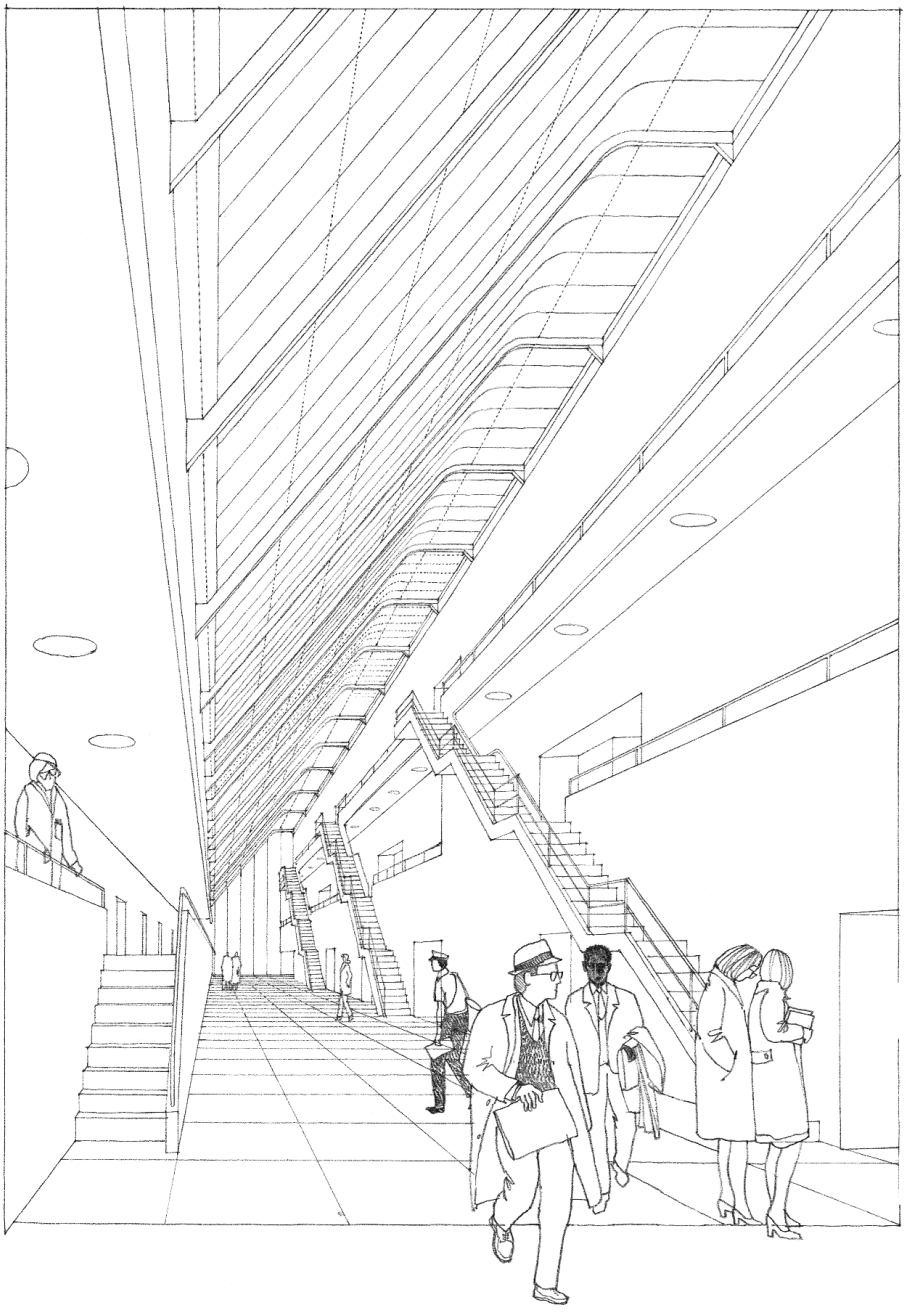
Companion Website: www.wiley.com/go/ching/architecturefso5e

CIRCULATION: MOVEMENT THROUGH SPACE

The path of our movement can be conceived as the perceptual thread that links the spaces of a building, or any series of interior or exterior spaces, together.

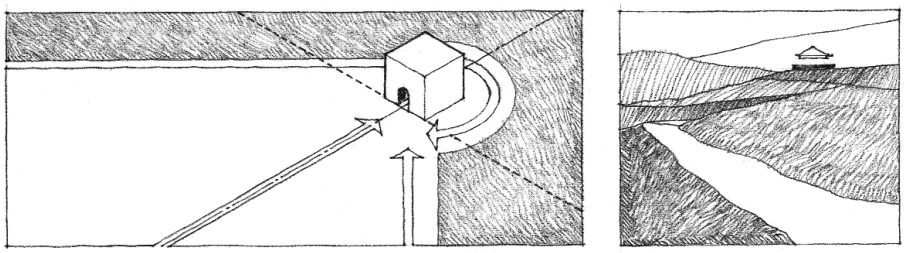
Since we move in ***Time***
through a ***Sequence***
of ***Spaces***,
we experience a space in relation to where we've been and where we anticipate going. This chapter presents the principal components of a building's circulation system as positive elements that affect our perception of the forms and spaces of the building.



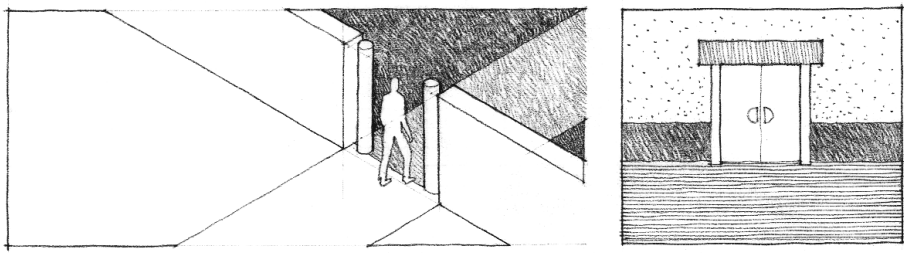


Skylighted Concourse, **Olivetti Headquarters** (Project), Milton Keynes, England, 1971, James Stirling & Michael Wilford

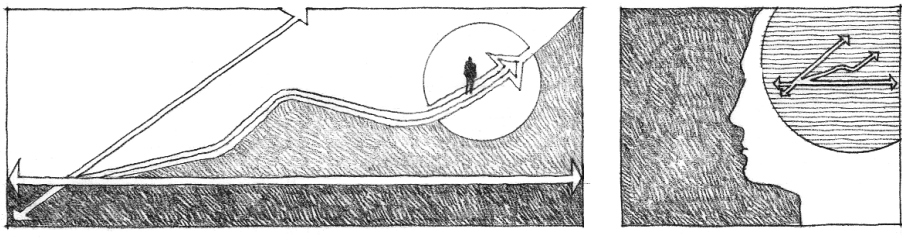
Approach
- The Distant View



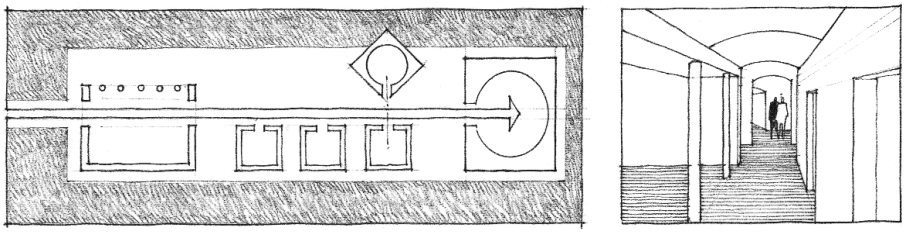
Entrance
- From Outside to Inside



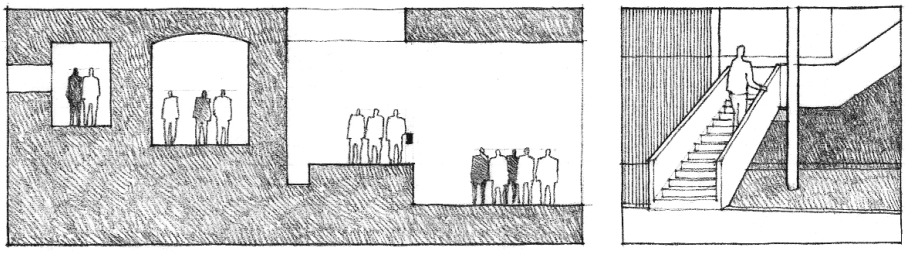
Configuration of the Path
- The Sequence of Spaces



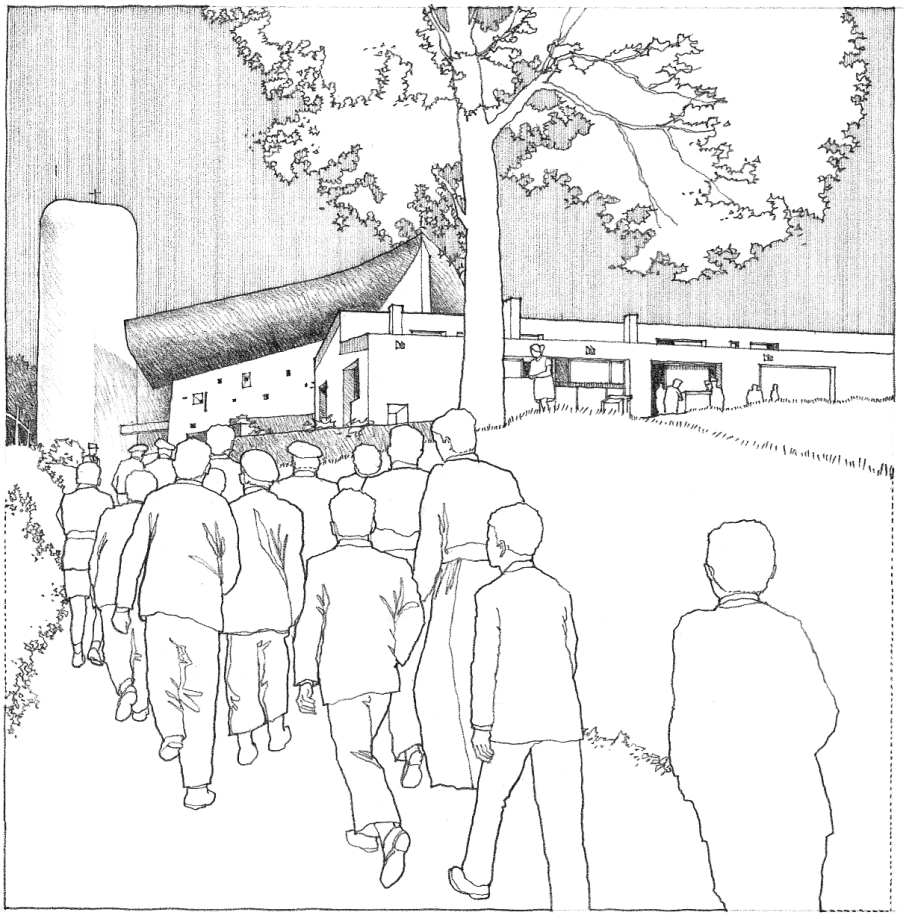
Path-Space Relationships
- Edges, Nodes, and Terminations of the Path



Form of the Circulation Space
- Corridors, Halls, Galleries, Stairways, and Rooms



APPROACH



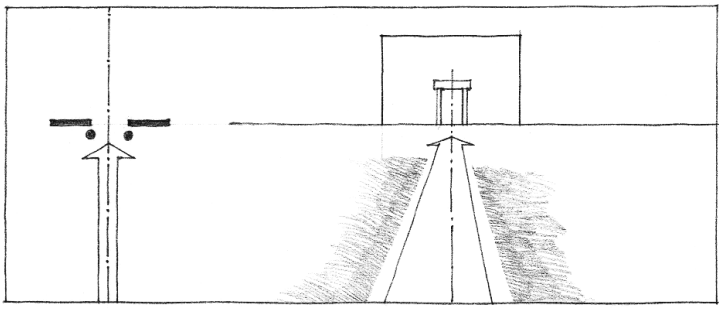
Approach to **Notre Dame Du Haut**, Ronchamp, France, 1950–1955, Le Corbusier

Prior to actually passing into the interior of a building, we approach its entrance along a path. This is the first phase of the circulation system, during which we are prepared to see, experience, and use the spaces within a building.

The approach to a building and its entrance may vary in duration from a few paces through a compressed space to a lengthy and circuitous route. It may be perpendicular to the primary facade of a building or be oblique to it. The nature of the approach may contrast with what is confronted at its termination, or it may be continued on into the building's interior sequence of spaces, obscuring the distinction between inside and outside.

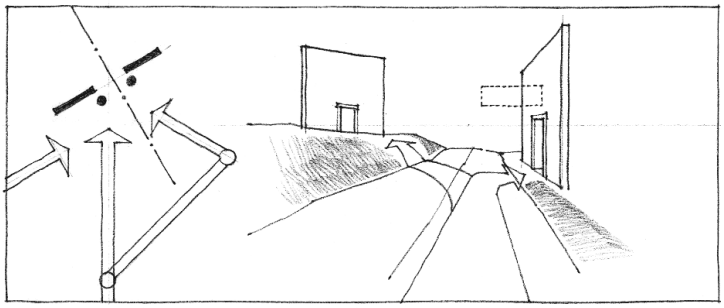
Frontal

A frontal approach leads directly to the entrance of a building along a straight, axial path. The visual goal that terminates the approach is clear; it may be the entire front facade of a building or an elaborated entrance within the plane.



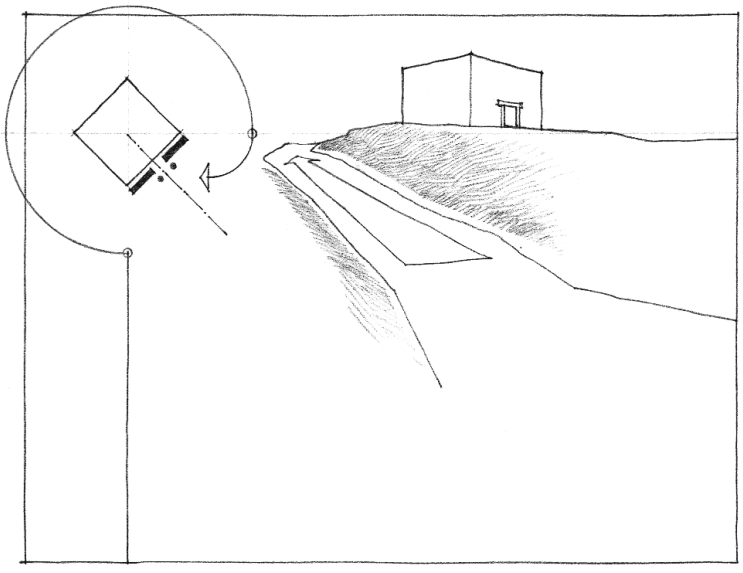
Oblique

An oblique approach enhances the effect of perspective on the front facade and form of a building. The path can be redirected one or more times to delay and prolong the sequence of the approach. If a building is approached at an extreme angle, its entrance can project beyond its facade to be more clearly visible.

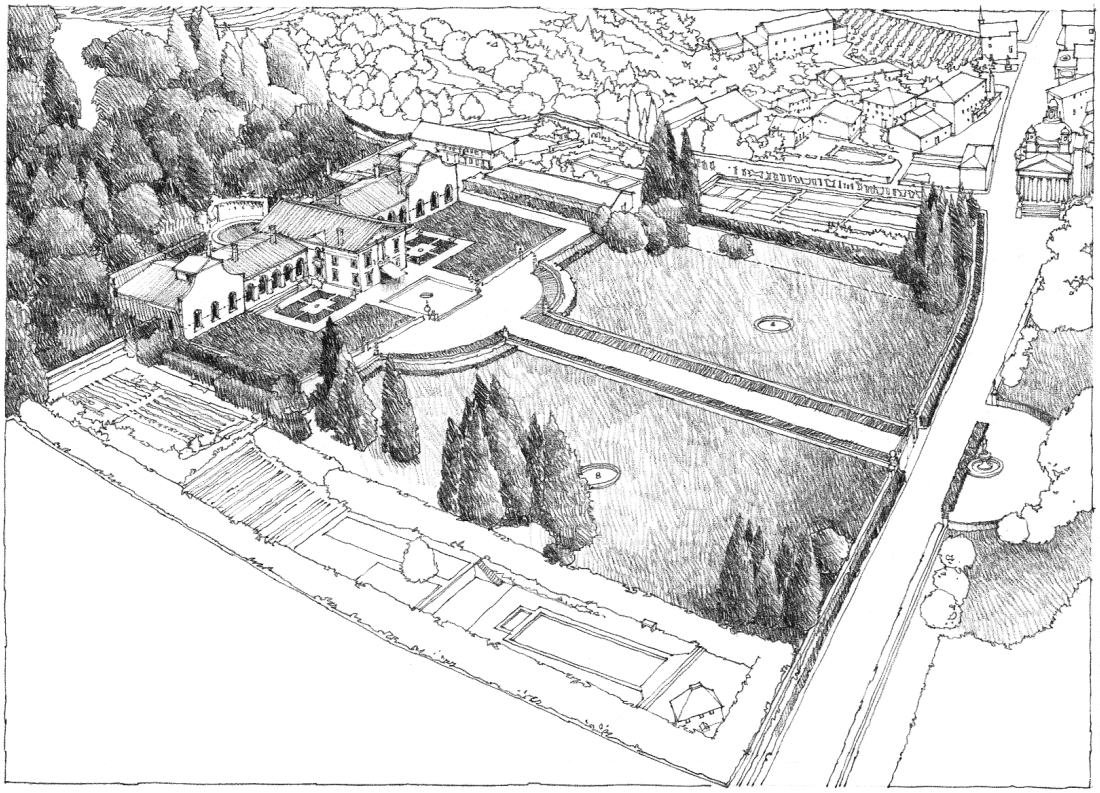


Spiral

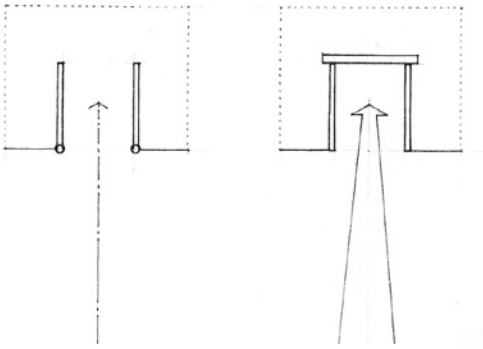
A spiral path prolongs the sequence of the approach and emphasizes the three-dimensional form of a building as we move around its perimeter. The building entrance might be viewed intermittently during the approach to clarify its position or it may be hidden until the point of arrival.

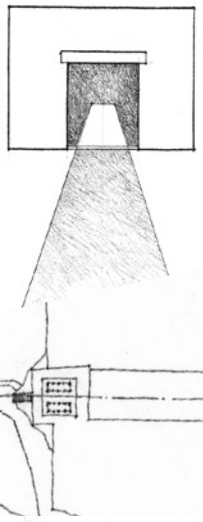


APPROACH

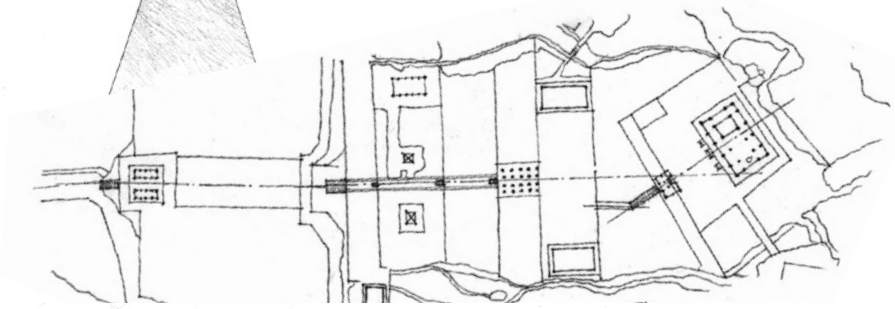


Villa Barbaro, Maser, Italy, 1560–1568, Andrea Palladio

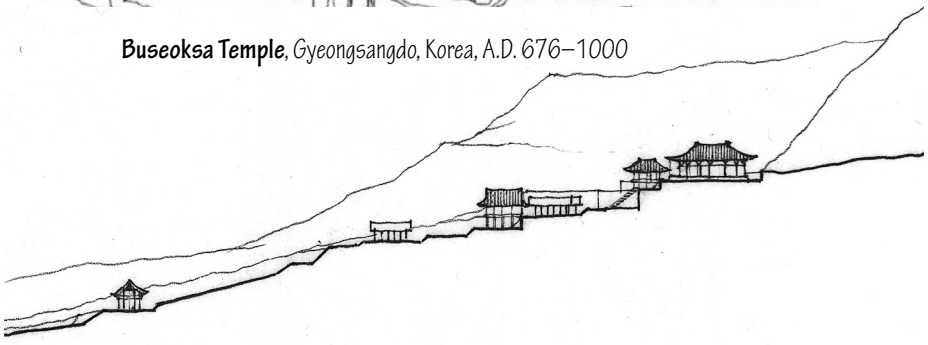


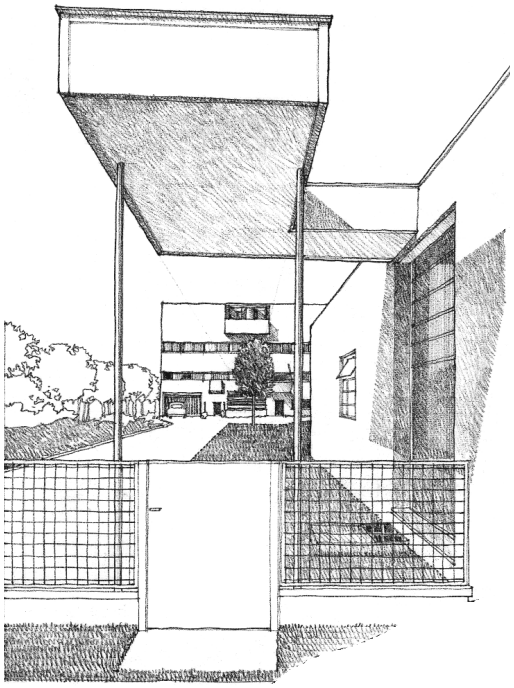


Portals and gateways have traditionally been means of orienting us to the path beyond and welcoming or guarding against our entry.

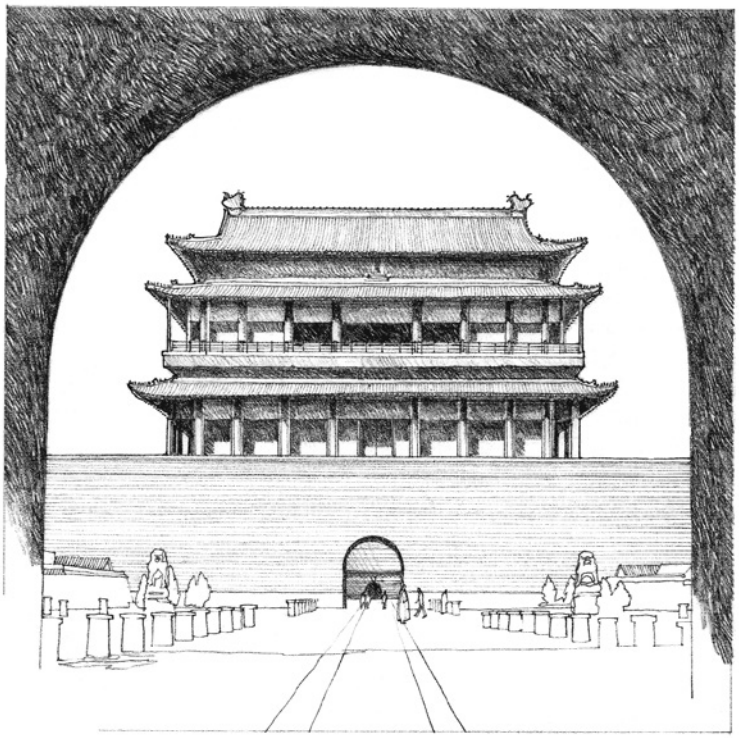


Buseoksa Temple, Gyeongsangdo, Korea, A.D. 676–1000

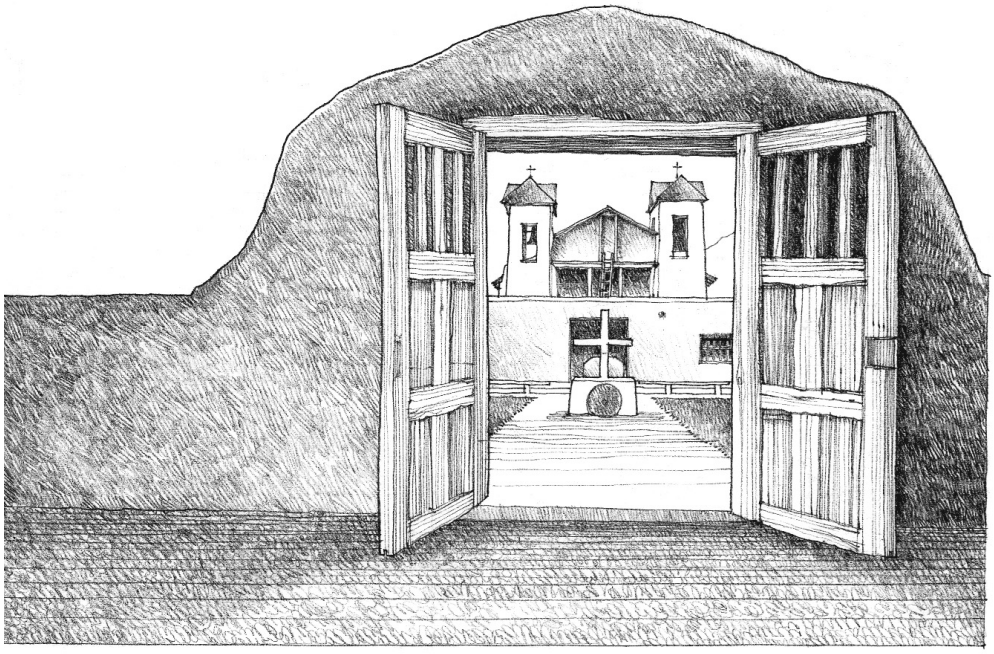




Villa Garches, Vaucresson, France, 1926–1927, Le Corbusier

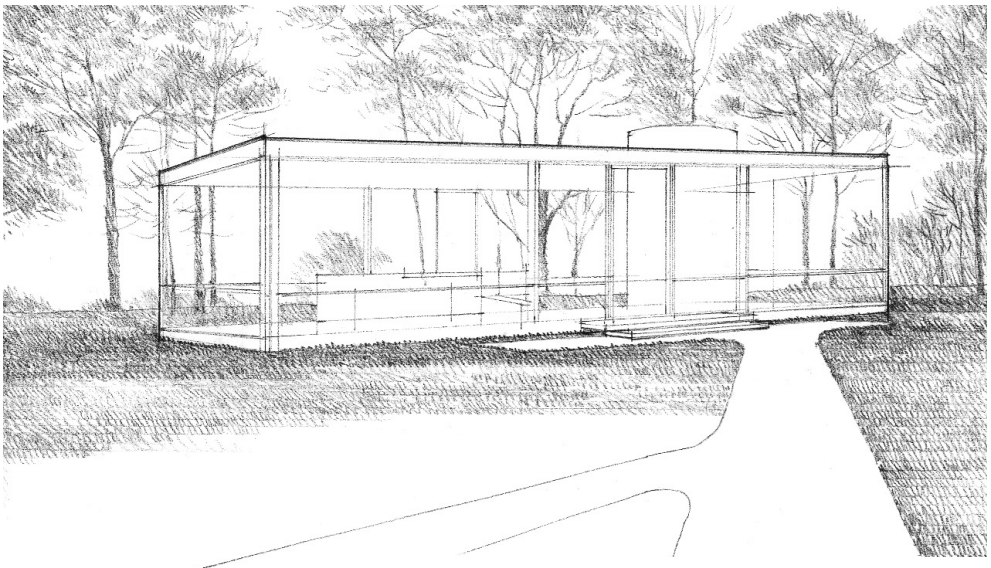


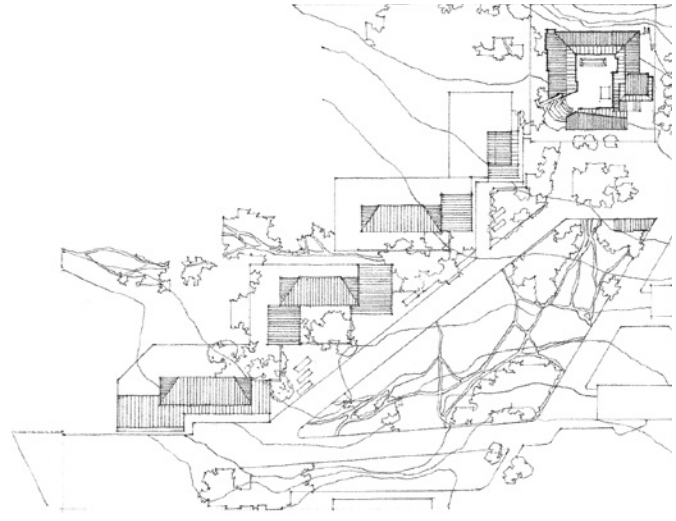
Qian Men, Link between the Forbidden City to the north and the Outer City to the south in Beijing, China, 15th century

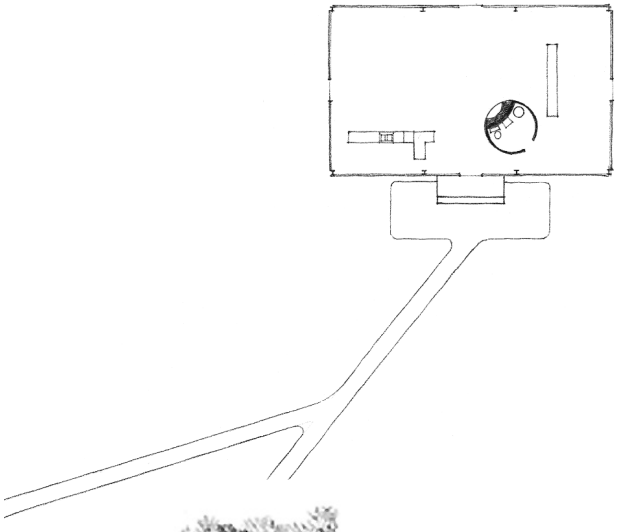


Catholic Church, Taos, New Mexico, 17th century

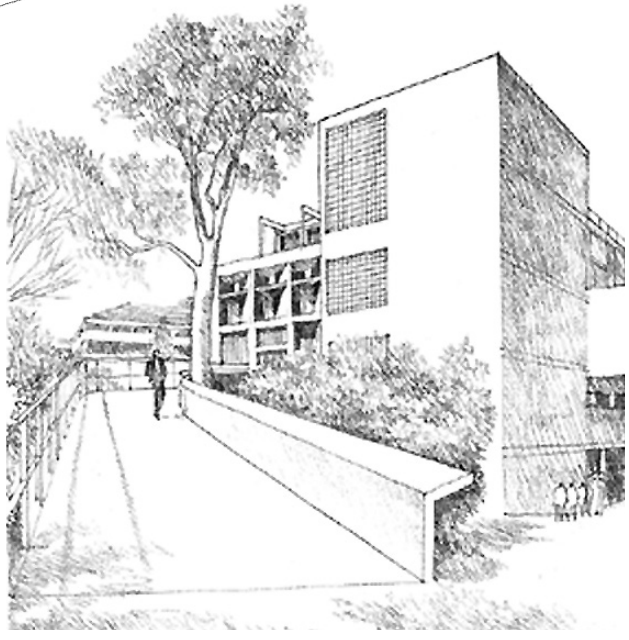
Glass House, New Canaan, Connecticut, 1949, Philip Johnson



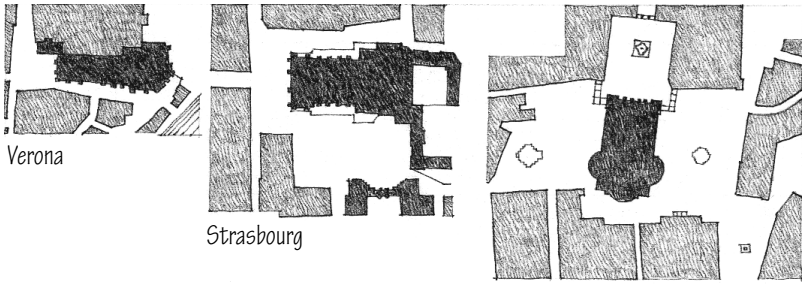




Site Plan, **Town Hall at Säynätsalo**, Finland, 1950–1952, Alvar Aalto



Ramp into and through the **Carpenter Center for the Visual Arts**, Harvard University, Cambridge, Massachusetts, 1961–1964, Le Corbusier

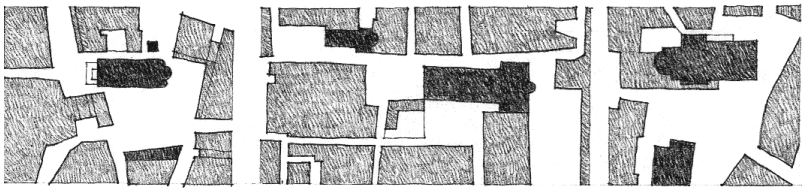


Verona

Strasbourg

Salzburg

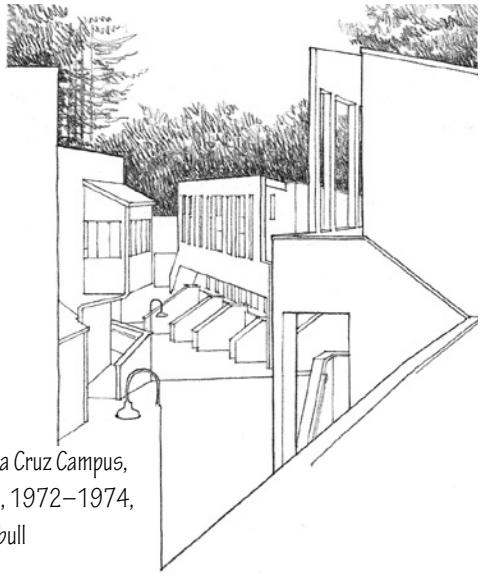
Drawings of church-dominated urban spaces by Camillo Sitte illustrate the asymmetrical, picturesque approach to the siting of buildings. Only fragments of the churches can be seen from various points in the squares.



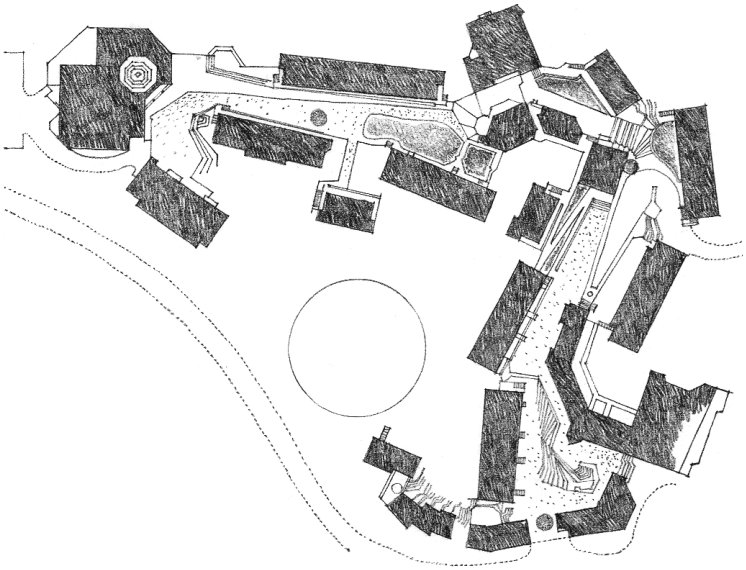
Modena

Lucca

Perugia

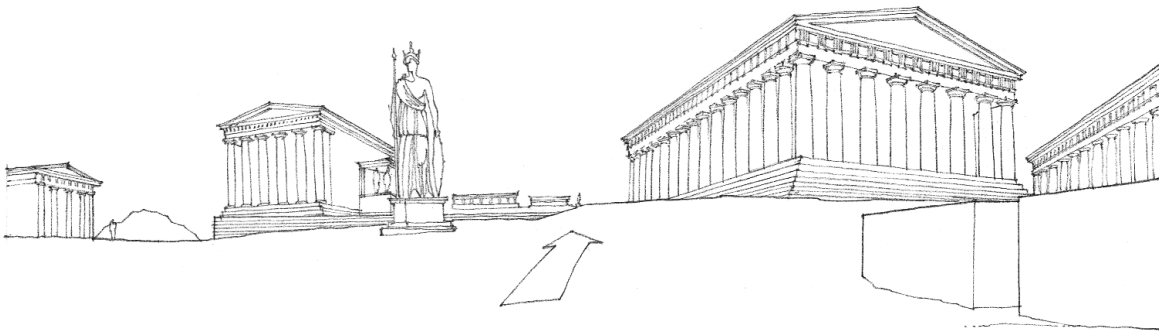


Kresge College, Santa Cruz Campus, University of California, 1972–1974, MLTW/Moore and Turnbull

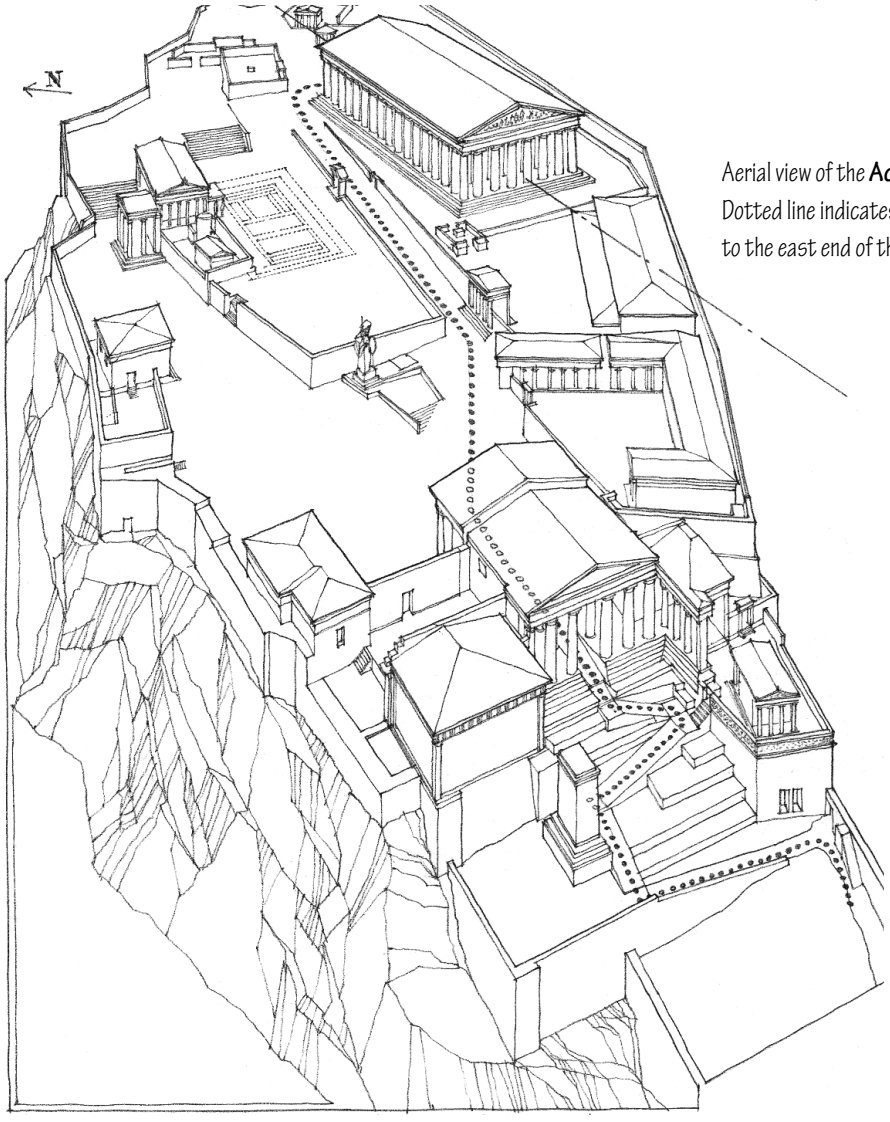


Street in Siena, Italy

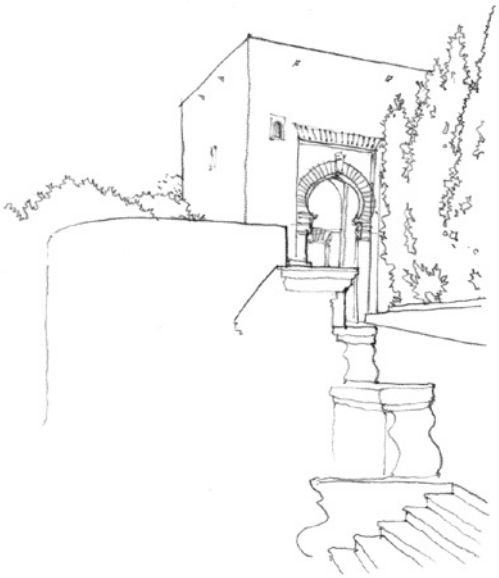
APPROACH



View looking east from the Propylaea

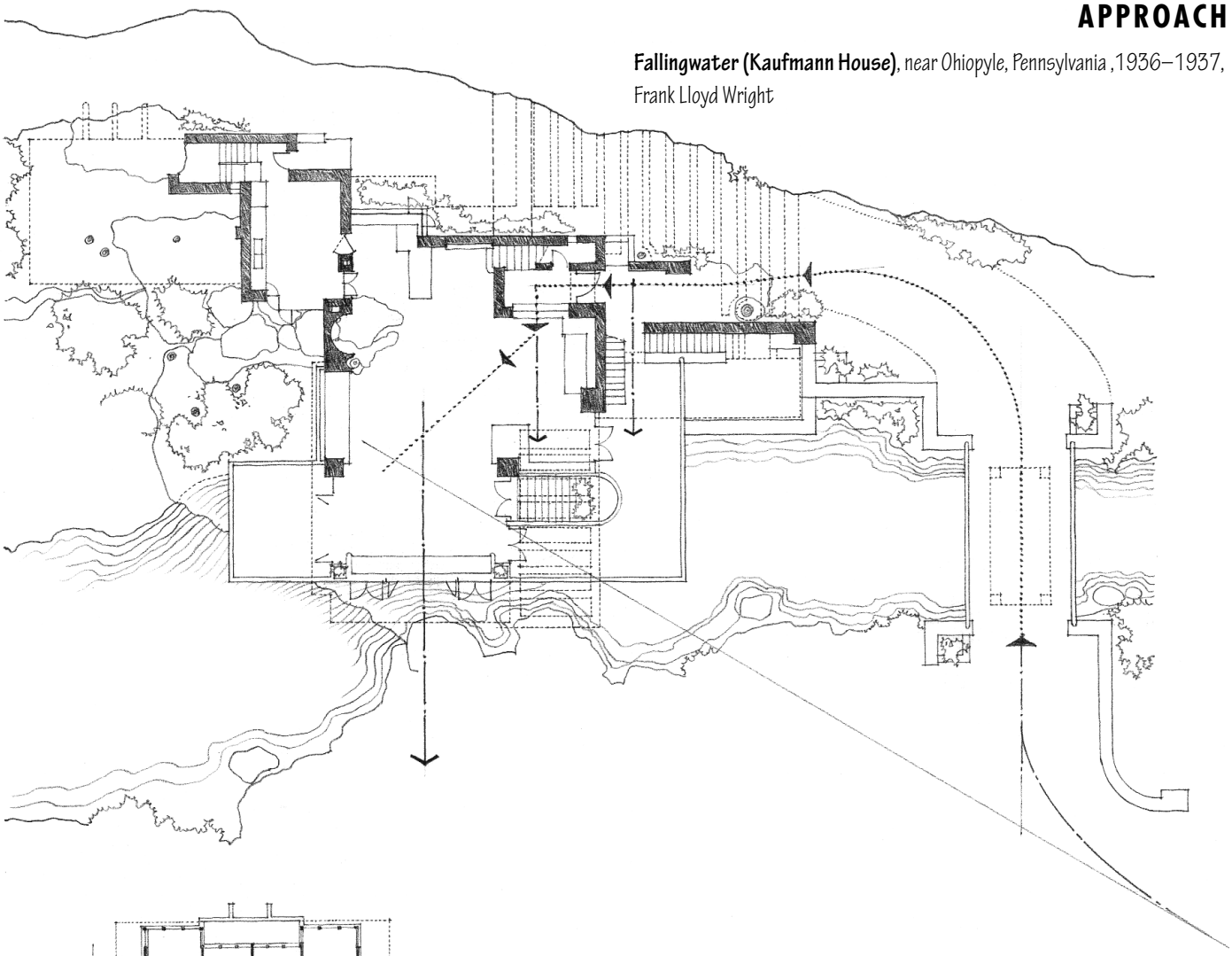


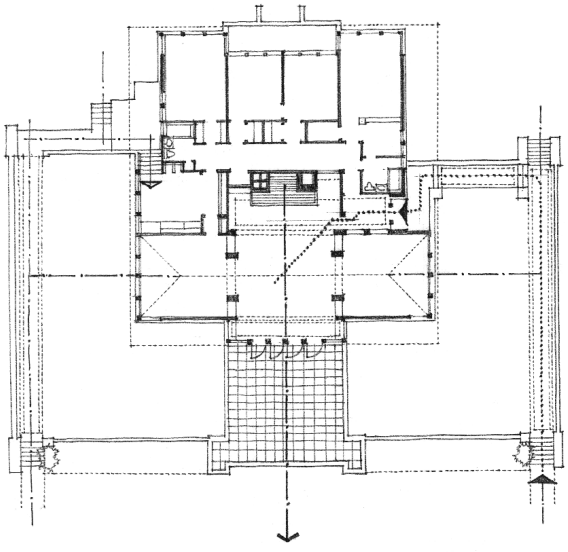
Aerial view of the **Acropolis**, Athens, Greece.
Dotted line indicates the path through the Propylaea
to the east end of the Parthenon.



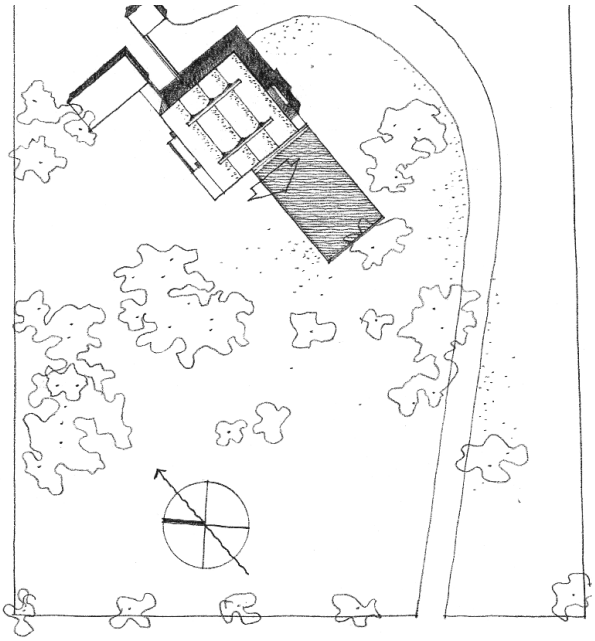
Gate of Justice, **Alhambra**, Granada, Spain,
1338–1390

Fallingwater (Kaufmann House), near Ohiopyle, Pennsylvania, 1936–1937, Frank Lloyd Wright



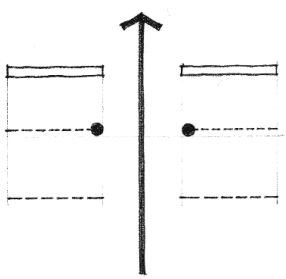


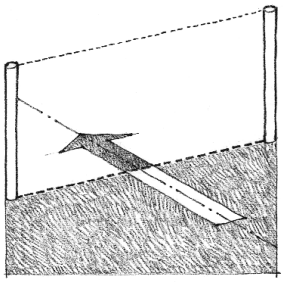
Edwin Cheney House, Oak Park, Illinois, 1904, Frank Lloyd Wright

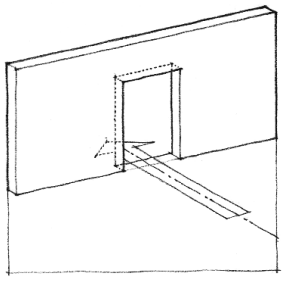


Villa Hutheesing (Project), Ahmedabad, India, 1952, Le Corbusier

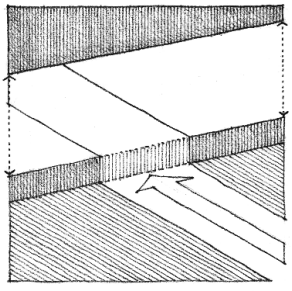
ENTRANCE

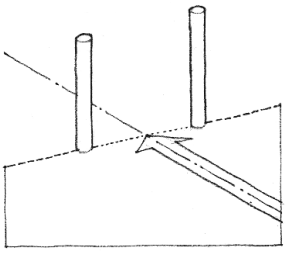


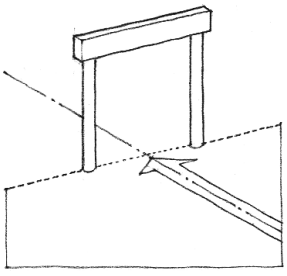




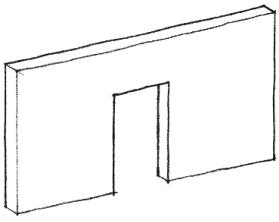
Entering a building, a room within a building, or a defined field of exterior space, involves the act of penetrating a vertical plane that distinguishes one space from another and separates "here" from "there."

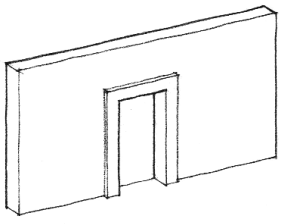


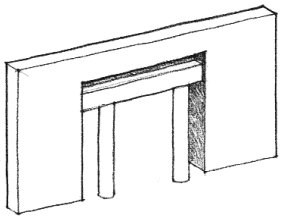




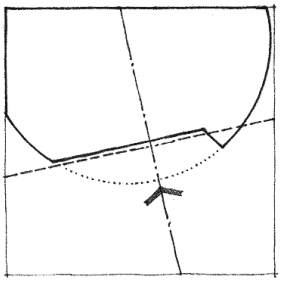
The act of entering can be signified in more subtle ways than punching a hole in a wall. It may be a passage through an implied plane established by two pillars or an overhead beam. In situations where greater visual and spatial continuity between two spaces is desired, even a change in level can establish a threshold and mark the passage from one place to another.

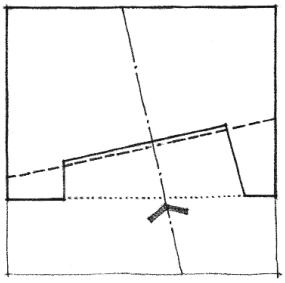


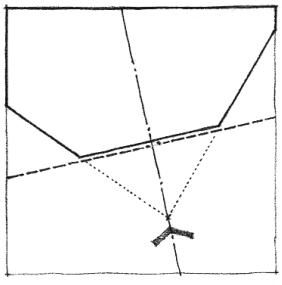




In the normal situation where a wall is used to define and enclose a space or series of spaces, an entrance is accommodated by an opening in the plane of the wall. The form of the opening, however, can range from a simple hole in the wall to an elaborate, articulated gateway.

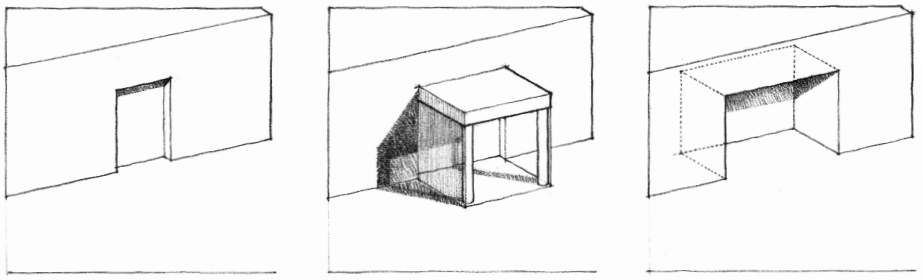




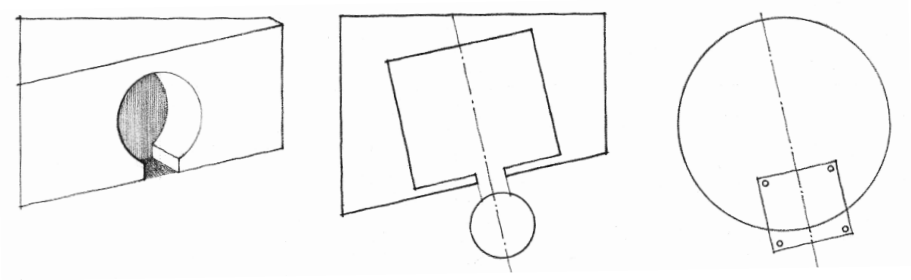


Regardless of the form of the space being entered or the form of its enclosure, the entrance into the space is best signified by establishing a real or implied plane perpendicular to the path of the approach.

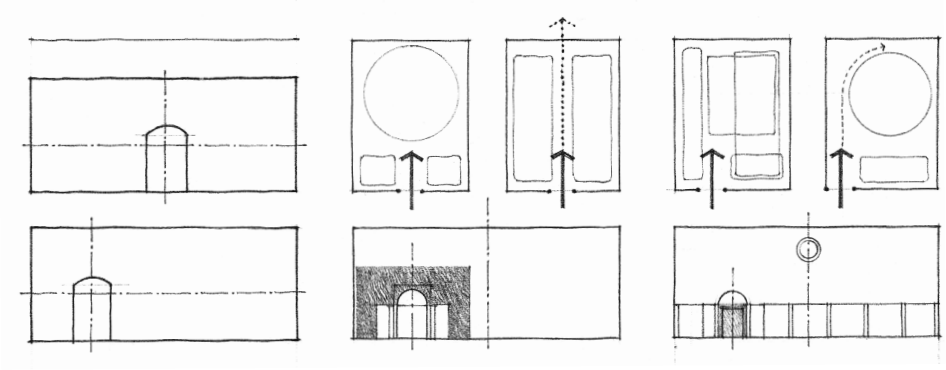
Entrances may be grouped formally into the following categories: flush, projected, and recessed. A flush entrance maintains the continuity of the surface of a wall and can be, if desired, deliberately obscured. A projected entrance forms a transitional space, announces its function to the approach, and provides overhead shelter. A recessed entrance also provides shelter and receives a portion of exterior space into the realm of the building.



In each of the above categories, the form of the entrance can be similar to, and serve as a preview of, the form of the space being entered. Or it can contrast with the form of the space to reinforce its boundaries and emphasize its character as a place.

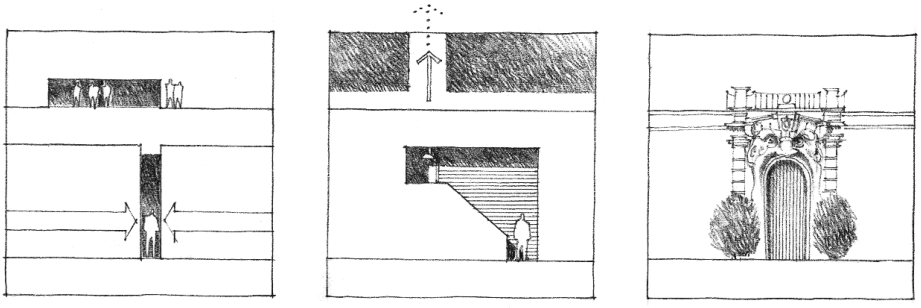


In terms of location, an entrance can be centered within the frontal plane of a building or be placed off-center to create a condition of local symmetry about its opening. The location of an entrance relative to the form of the space being entered will determine the configuration of the path and the pattern of the activities within the space.



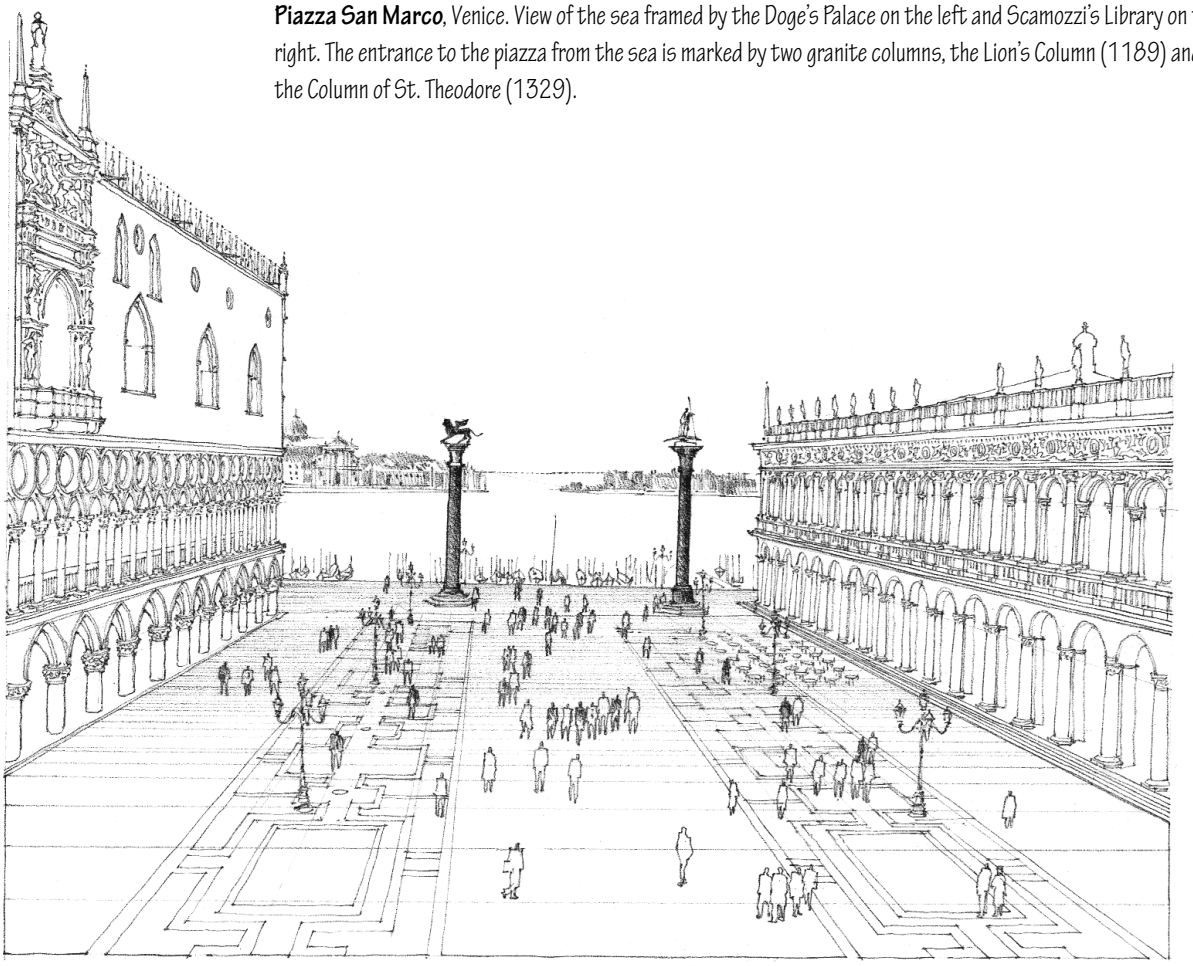
The notion of an entrance can be visually reinforced by:

- Making the opening lower, wider, or narrower than anticipated
- Making the entrance deep or circuitous
- Articulating the opening with ornamentation or decorative embellishment

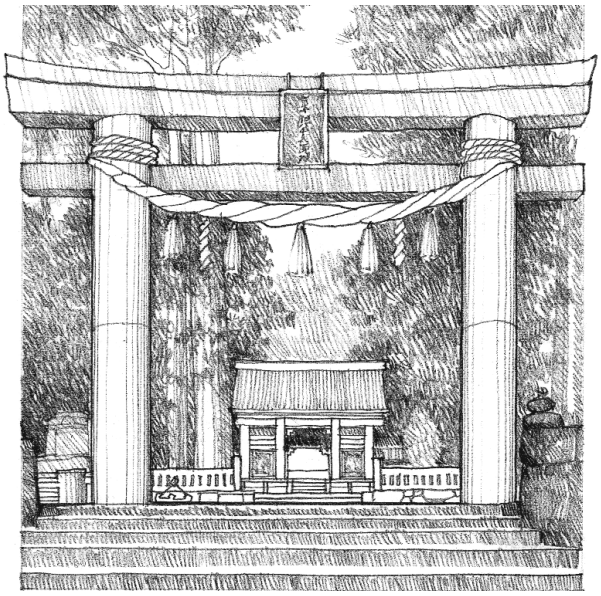


Palazzo Zuccari, Rome, c. 1592, Federico Zuccari

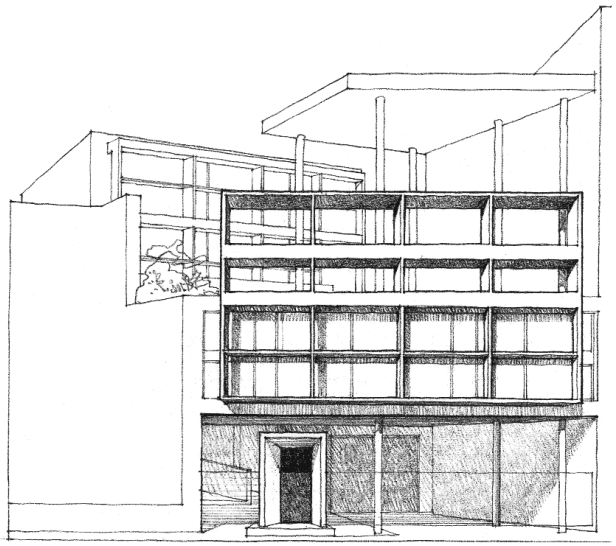
ENTRANCE



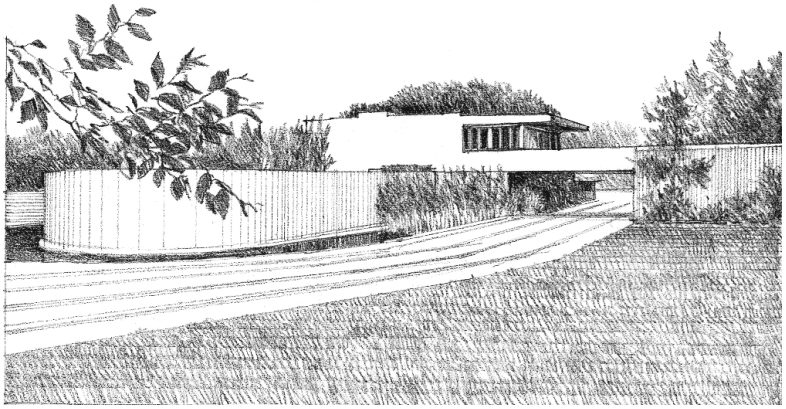
Piazza San Marco, Venice. View of the sea framed by the Doge's Palace on the left and Scamozzi's Library on the right. The entrance to the piazza from the sea is marked by two granite columns, the Lion's Column (1189) and the Column of St. Theodore (1329).



O-torii, first gate to the **Toshogu Shrine**, Nikko, Tochigi Prefecture, Japan, 1636

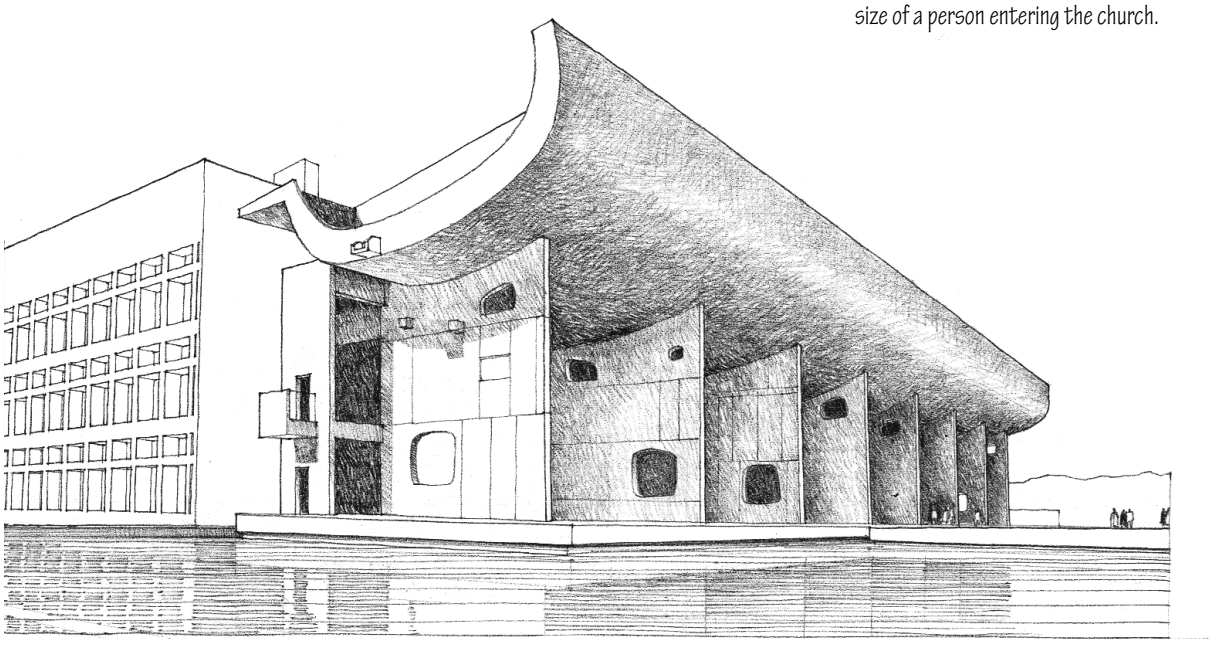


Dr. Currutchet's House, La Plata, Argentina, 1949, Le Corbusier. A portal marks the entrance for pedestrians within a larger opening that includes space for a carport.



Von Sternberg House, Los Angeles, California, 1936, Richard Neutra.
A curving drive leads to an entranceway for automobiles while the front door to the interior of this residence is in an entry court beyond.

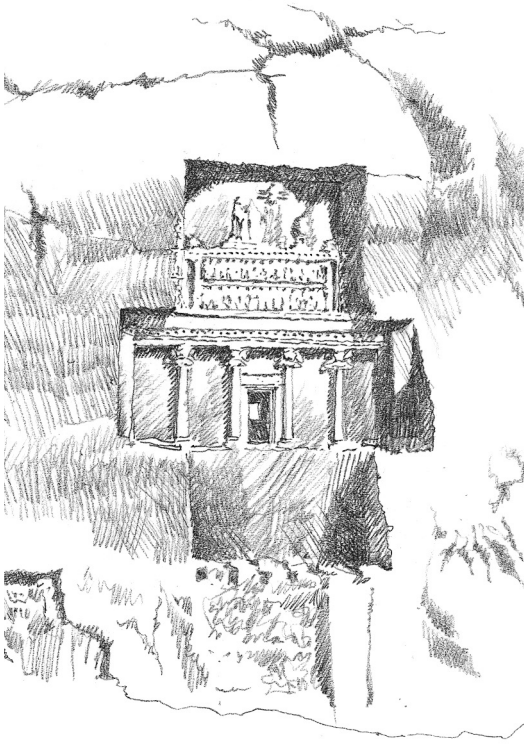
St. Giorgio Maggiore, Venice, 1566–1610, Andrea Palladio. Facade completed by Vicenzo Scamozzi.
The entrance facade operates at two scales: that of the building as a whole facing a public space and another at the size of a person entering the church.



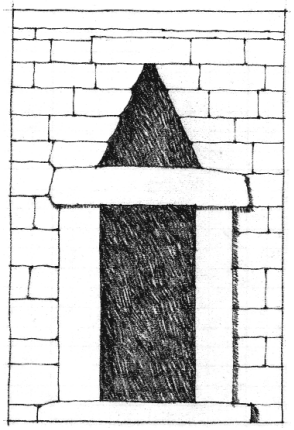
Legislative Assembly Building, **Chandigarh**, Capitol Complex of Punjab, India, 1956–1959, Le Corbusier.
The entrance colonnade is scaled to the public nature of the building.

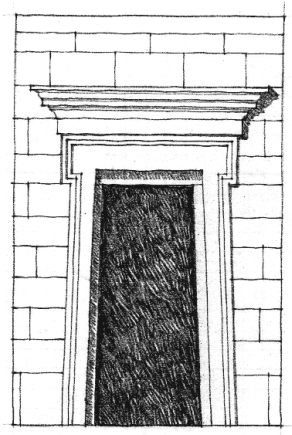
ENTRANCE

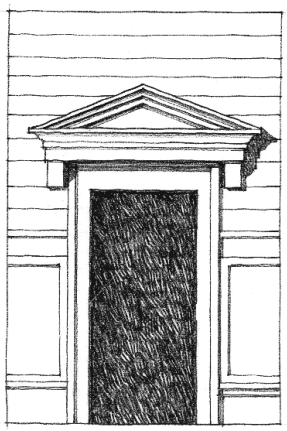
Katsura Imperial Villa, Kyoto, Japan, 17th century.
While the fence separates, the gateway and the stepping stones provide continuity between the Imperial Carriage Stop and the Gepparo (Moon-Wave Pavilion) beyond.

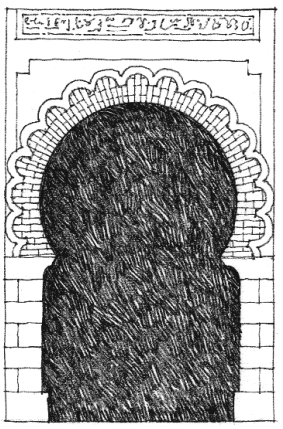


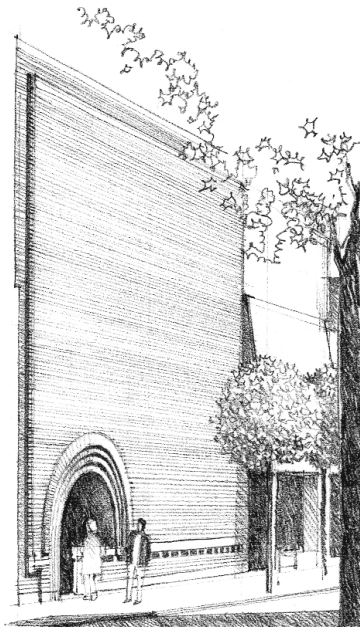
Rock of Naqsh-i-Rustam, near Persepolis, Iran, 3rd century A.D.



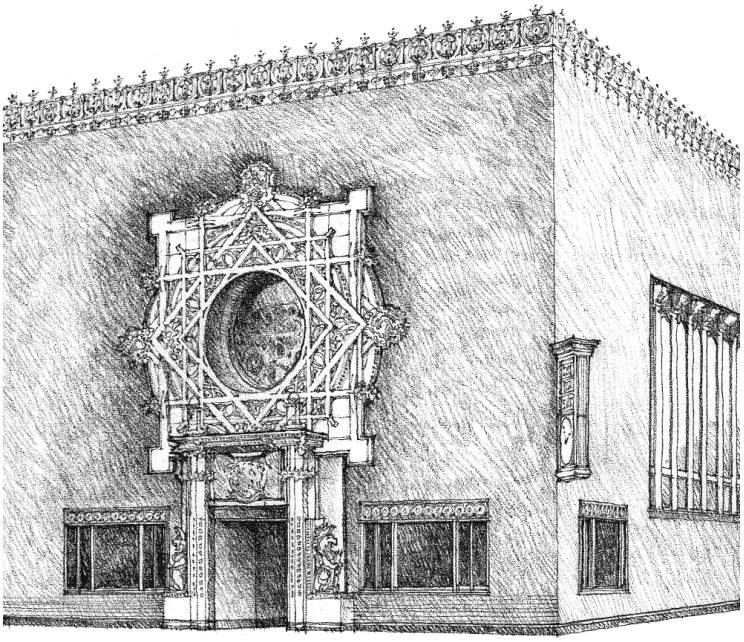






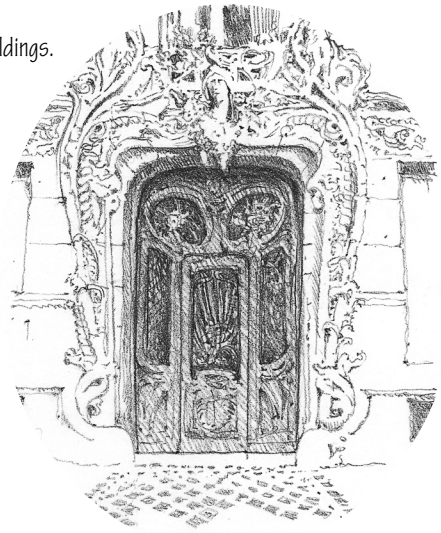


Morris Gift Shop, San Francisco, California, 1948–1949, Frank Lloyd Wright

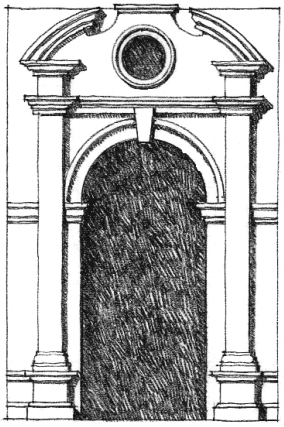


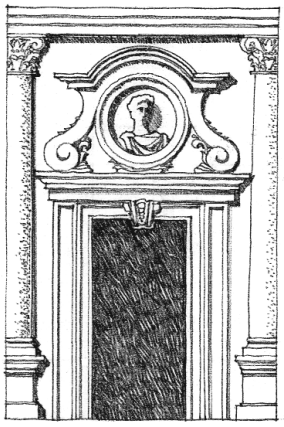
Merchants' National Bank, Grinnell, Iowa, 1914, Louis Sullivan

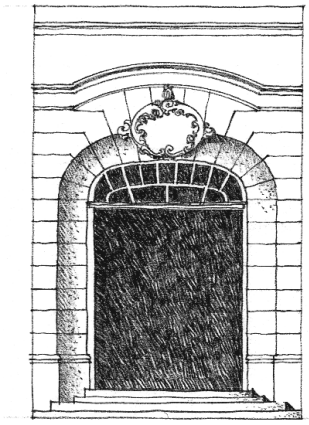
Elaborated openings within vertical planes mark the entrances to these two buildings.

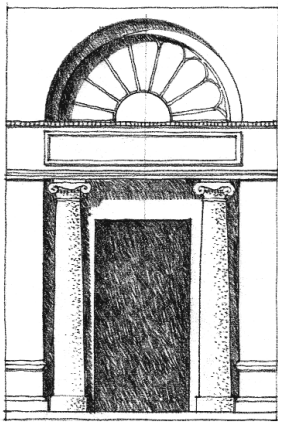


Art nouveau doorway in Paris, France

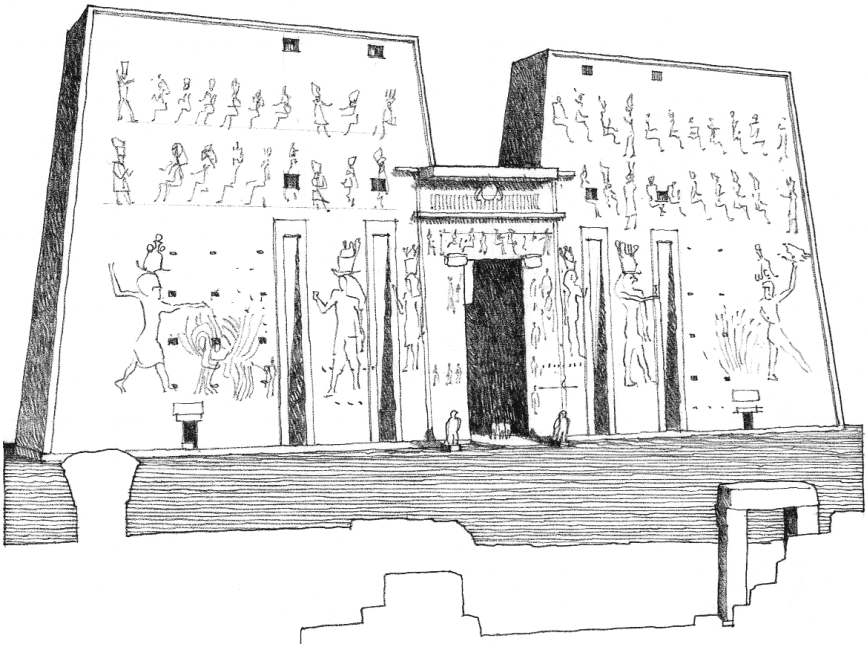






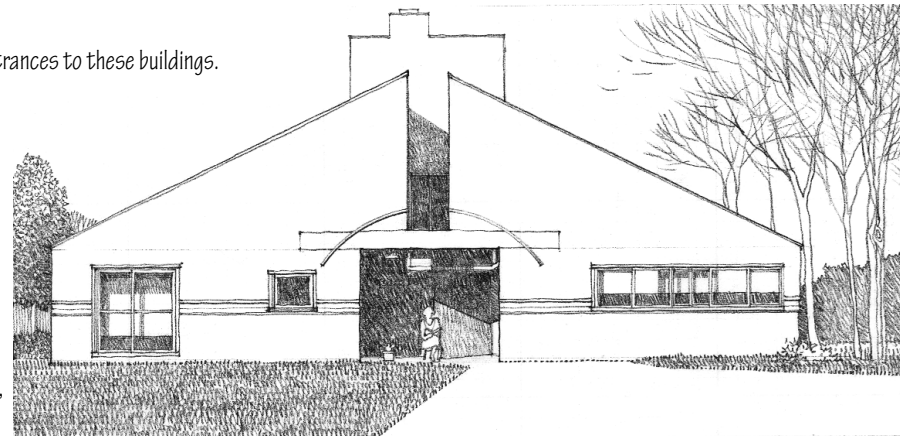


ENTRANCE

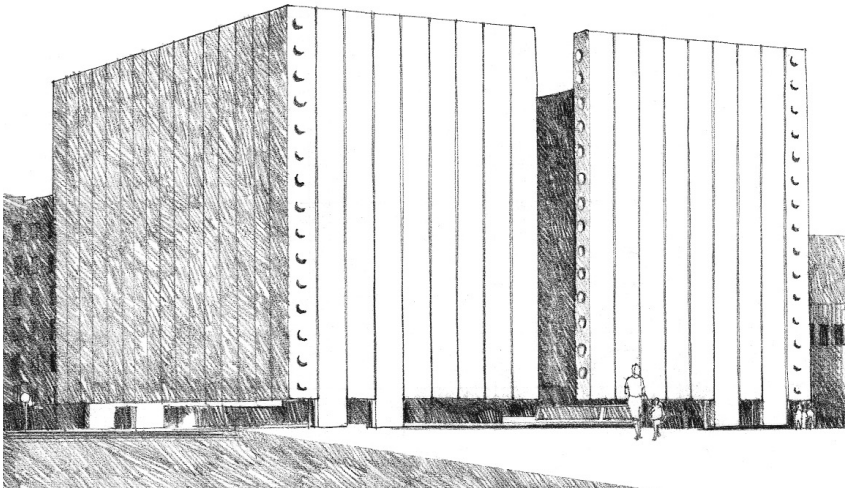


Entrance Pylons, **Temple of Horus at Edfu**, 257–37 B.C.

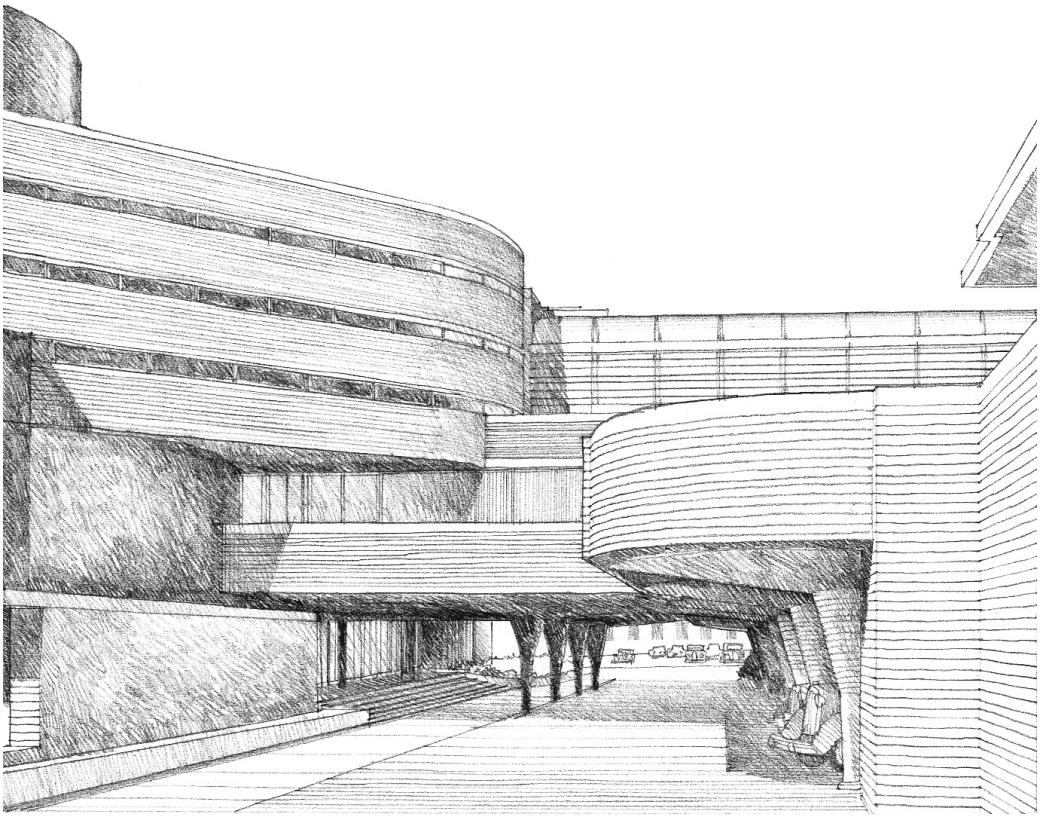
A vertical break or separation in the facade defines the entrances to these buildings.



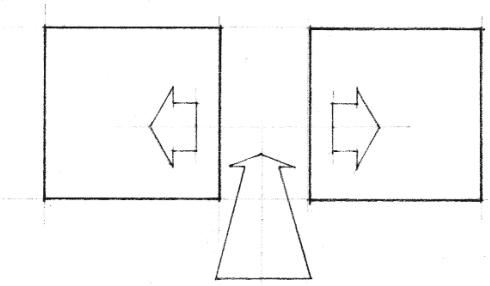
House for Mrs. Robert Venturi, Chestnut Hill, Pennsylvania, 1962–1964, Venturi and Short

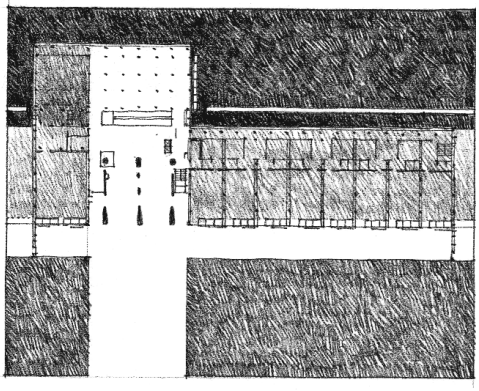


John F. Kennedy Memorial, Dallas, Texas, 1970, Philip Johnson



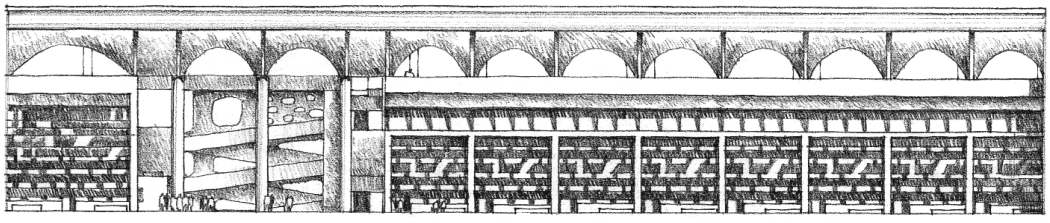
Entrance to the **Administration Building**, **Johnson Wax Co.**, Racine, Wisconsin, 1936–1939, Frank Lloyd Wright





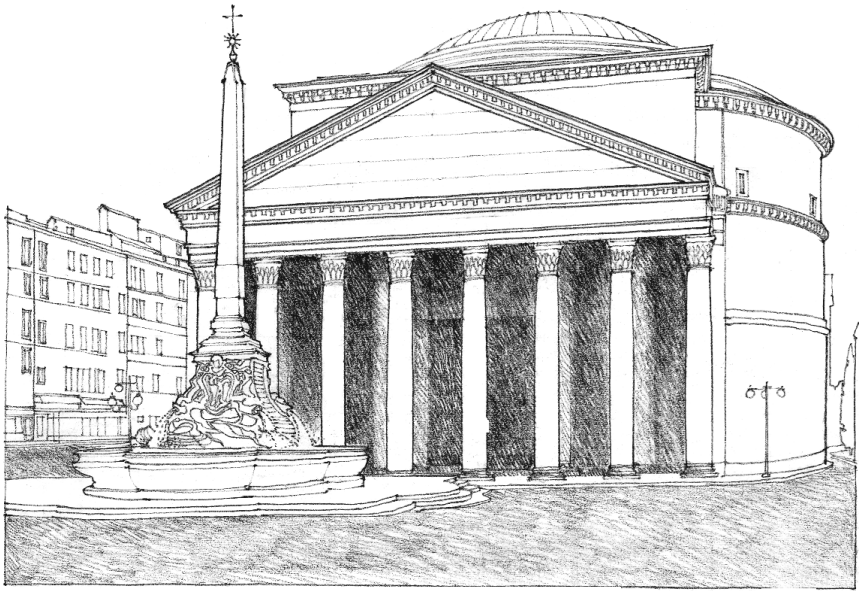
High Court, **Chandigarh**, Capitol Complex of Punjab, India, 1956, Le Corbusier

Plan Diagram

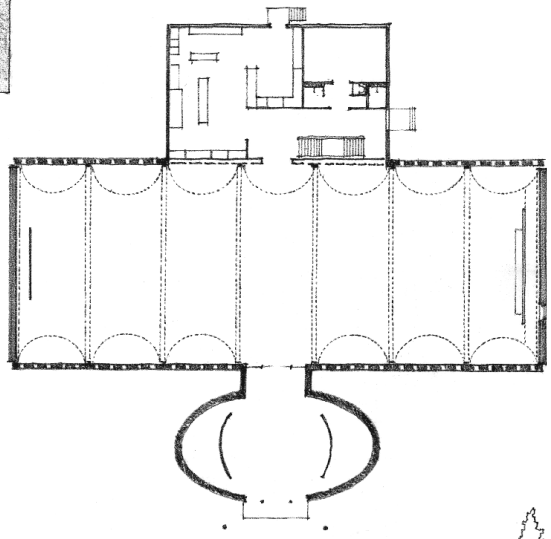


North Elevation

ENTRANCE

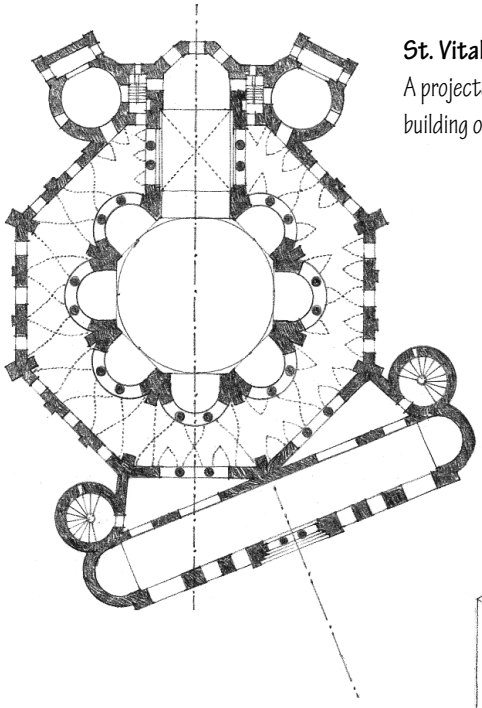


The Pantheon, Rome, A.D. 120–124.
Entrance portico reconstructed from an earlier temple of 25 B.C.

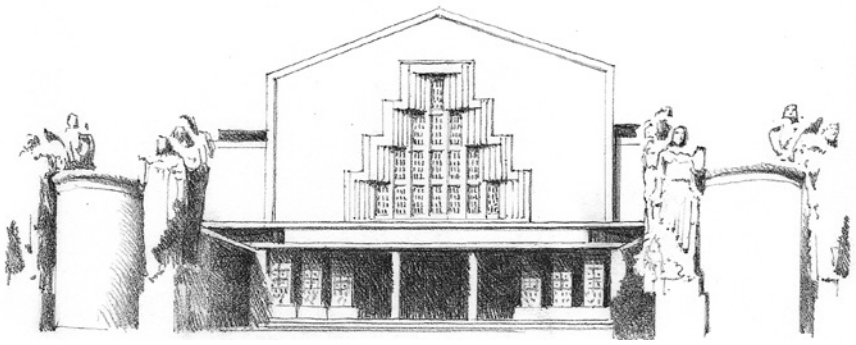


Kneses Tifereth Israel Synagogue,
Port Chester, New York, 1954, Philip Johnson

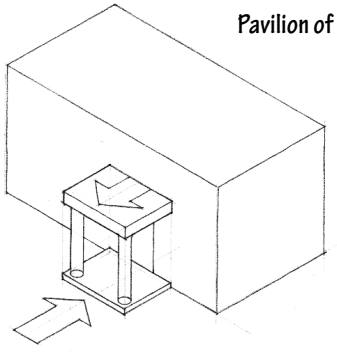
Pazzi Chapel, added to the Cloister of Santa Croce, Florence, Italy, 1429–1446, Filippo Brunelleschi



St. Vitale, Ravenna, Italy, A.D. 526–546
A projected entry space can reorient the principal axis of a building organization to that of the exterior space it fronts.



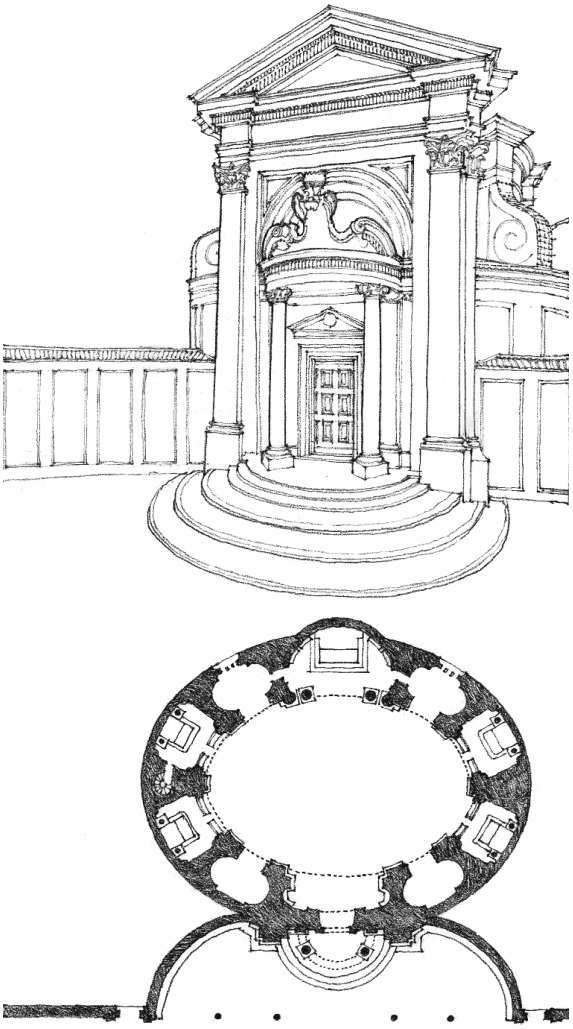
Pavilion of Commerce, 1908 Jubilee Exhibition, Prague, Jan Kotera



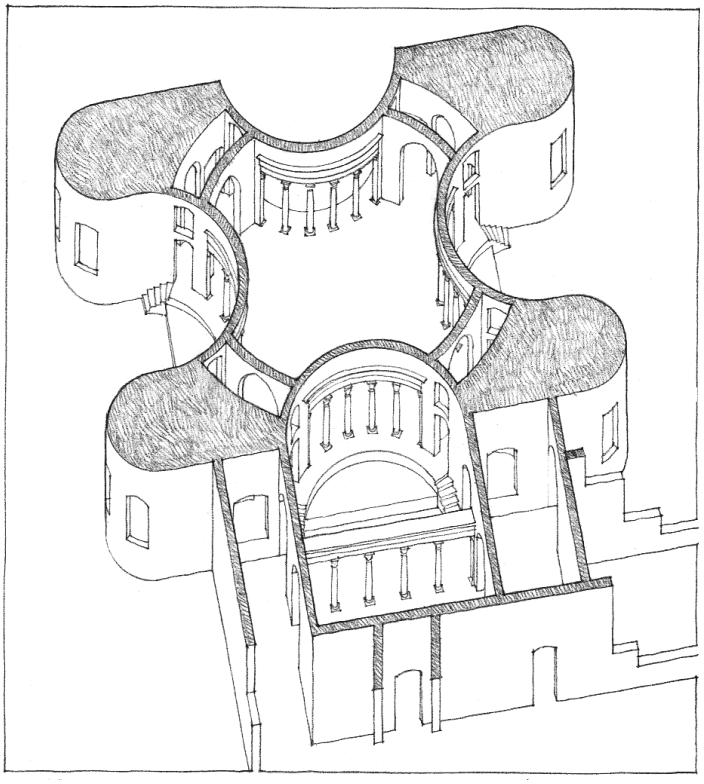
Porches, porticos, and marquees project from the main mass of a building to provide shelter, welcome, and announce the point of entry.

House in Milwaukee, Wisconsin

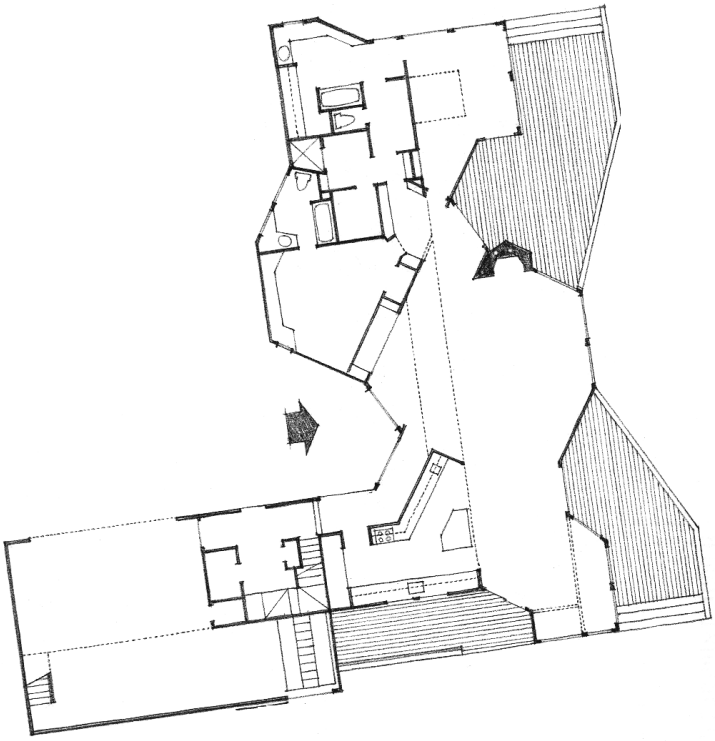
The Oriental Theater, Milwaukee, Wisconsin, 1927, Dick and Bauer



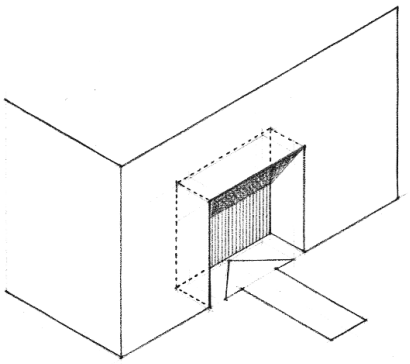
St. Andrea del Quirinale, Rome, 1670, Giovanni Bernini



Pavilion of the Academia, **Hadrian's Villa**, Tivoli, Italy, A.D. 118–125
(after a drawing by Heine Kahler)



Gagarin House, Peru, Vermont, 1968, MLTW/Moore-Turnbull



Examples of spaces recessed to receive those entering a building.

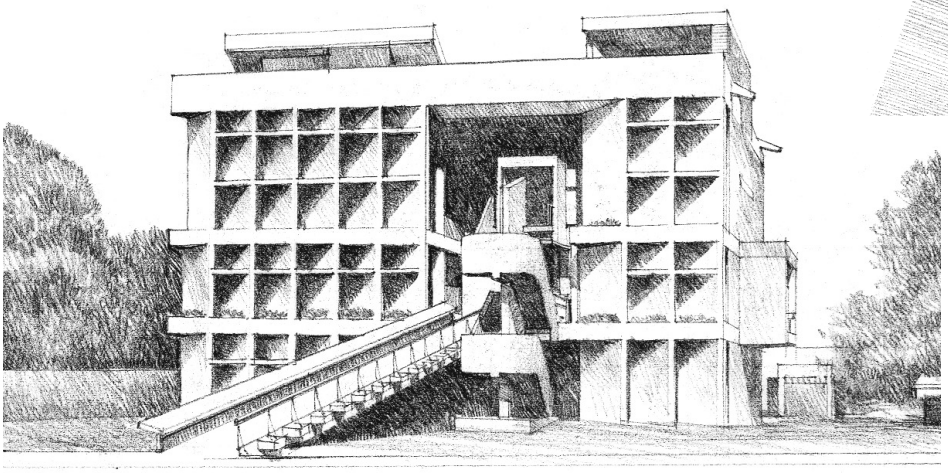
St. Andrea, Mantua, Italy 1472–1494, Leon Battista Alberti

East Building, **National Gallery of Art**, Washington, D.C., 1978, I.M. Pei and Partners

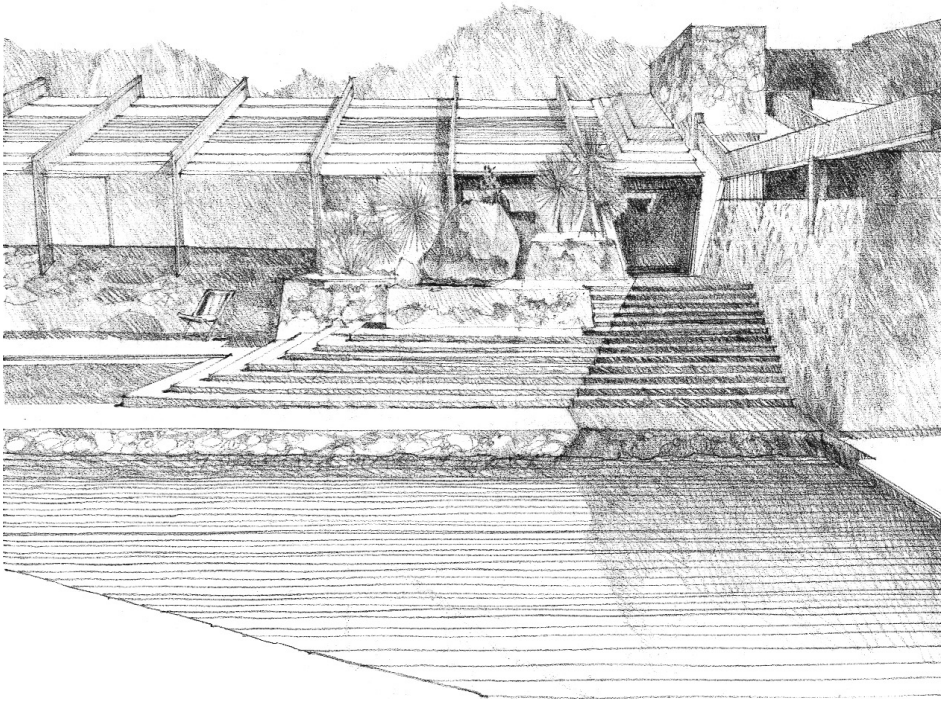
ENTRANCE

Steps and ramps introduce a vertical dimension and add a temporal quality to the act of entering a building.

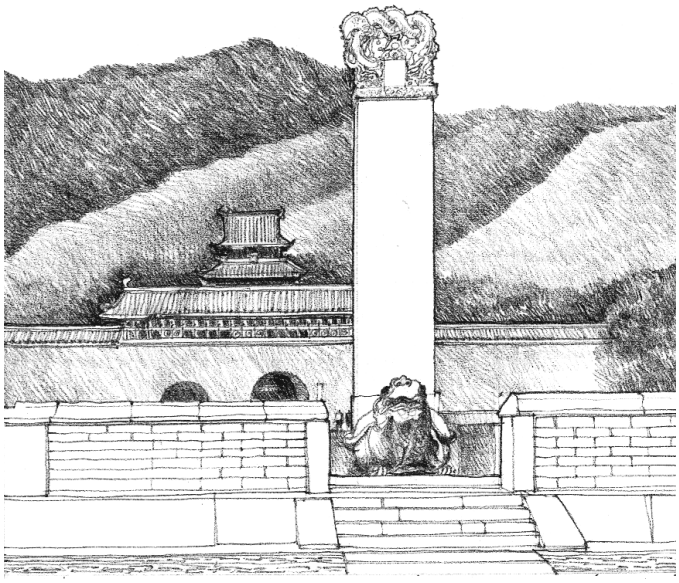
Rowhouses in Galena, Illinois



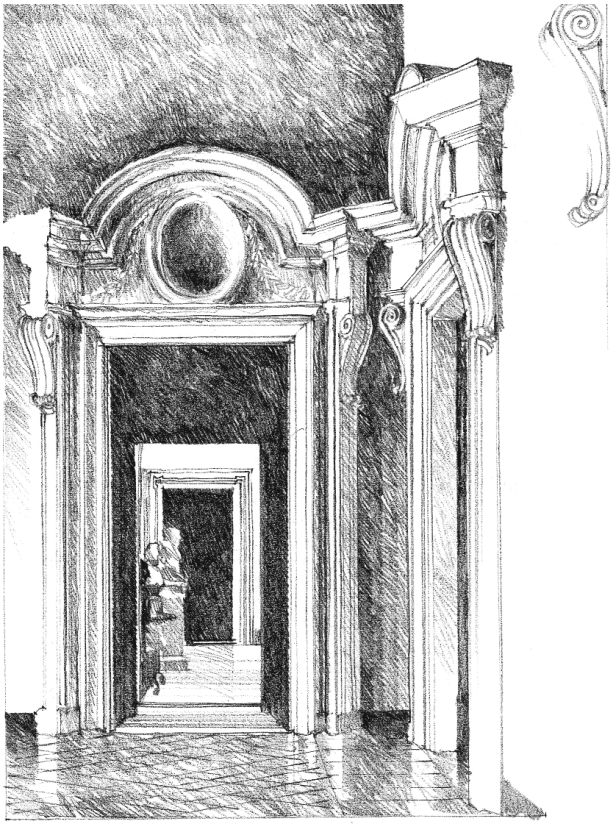
Millowners' Association Building, Ahmedabad, India, 1954, Le Corbusier



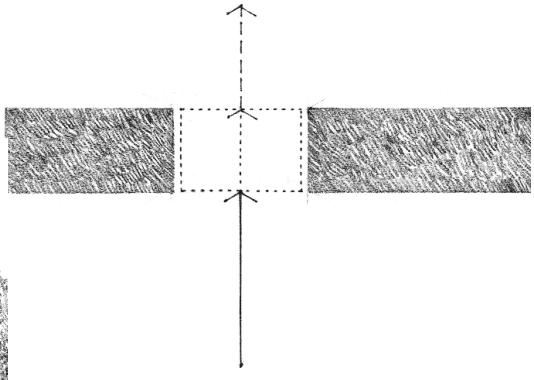
Taliesin West, near Phoenix, Arizona, 1938, Frank Lloyd Wright



A stele and tortoise guard the **Tomb of Emperor Wan Li** (1563–1620), northwest of Beijing, China.



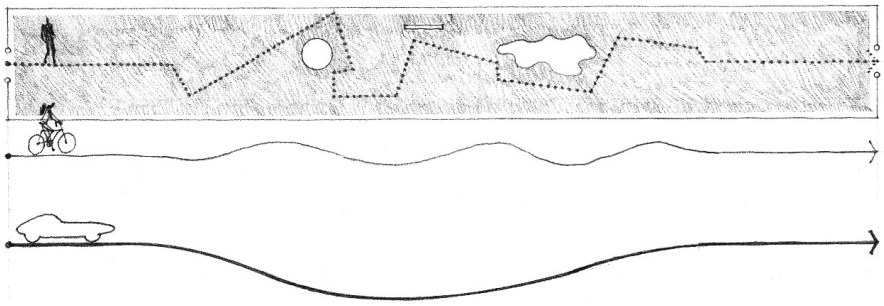
Interior Doorway by Francesco Borromini



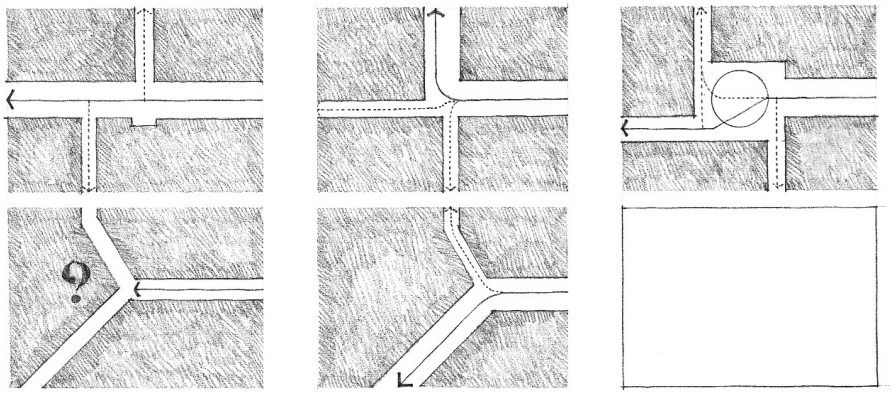
Entrances that pierce thick walls create transitional spaces through which one passes in moving from one place to another.

Santa Barbara Courthouse, California, 1929, William Mooser. The main entrance frames a view to the garden and hills beyond.

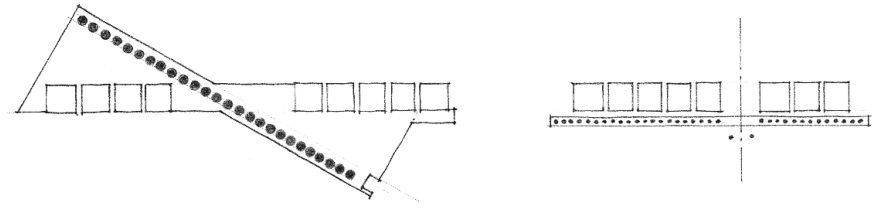
CONFIGURATION OF THE PATH



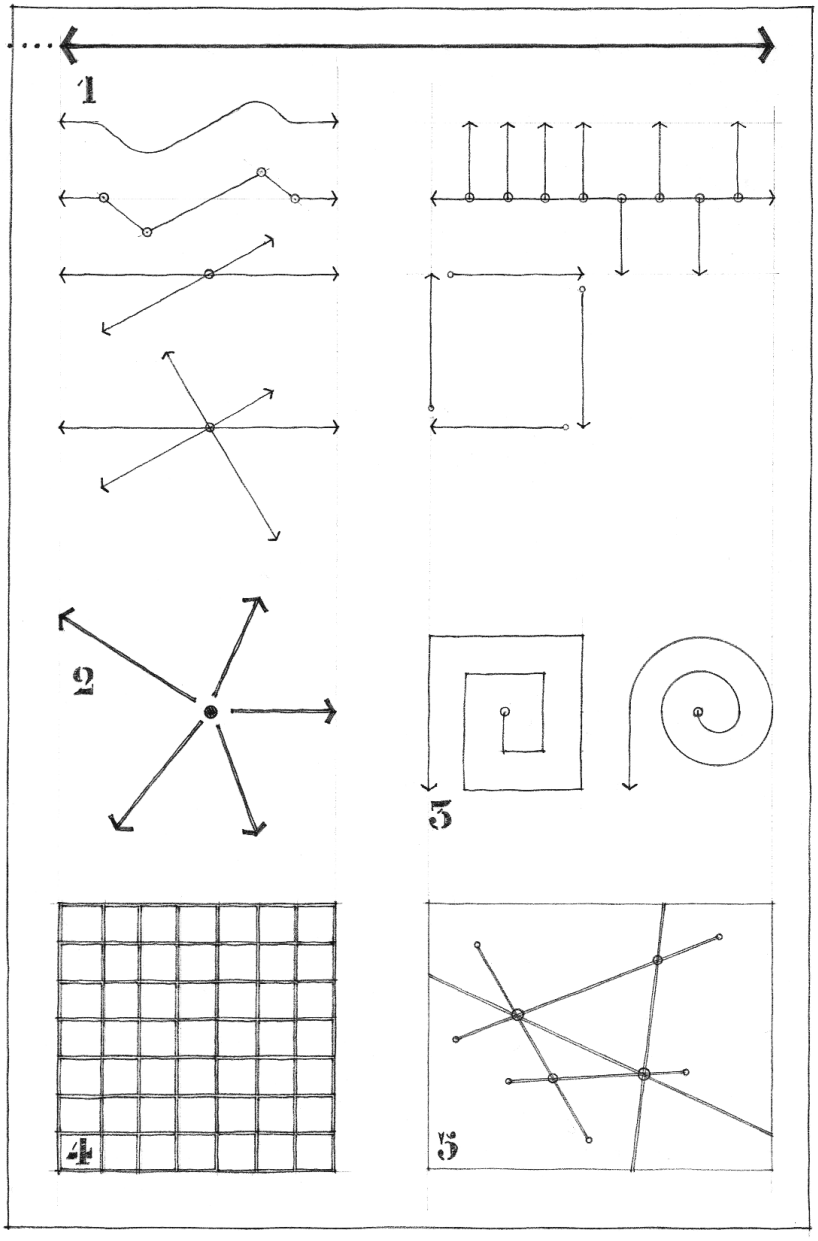
All paths of movement, whether of people, cars, goods, or services, are linear in nature. And all paths have a starting point, from which we are taken through a sequence of spaces to our destination. The contour of a path depends on our mode of transportation. While we as pedestrians can turn, pause, stop, and rest at will, a bicycle has less freedom, and a car even less, in changing its pace and direction abruptly. Interestingly though, while a wheeled vehicle may require a path with smooth contours that reflect its turning radius, the width of the path can be tailored tightly to its dimensions. Pedestrians, on the other hand, although able to tolerate abrupt changes in direction, require a greater volume of space than their bodily dimensions and greater freedom of choice along a path.



The intersection or crossing of paths is always a point of decision-making for the person approaching it. The continuity and scale of each path at an intersection can help us distinguish between major routes leading to major spaces and secondary paths leading to lesser spaces. When the paths at a crossing are equivalent to each another, sufficient space should be provided to allow people to pause and orient themselves. The form and scale of entrances and paths should also convey the functional and symbolic distinction between public promenades, private halls, and service corridors.



The nature of the configuration of a path both influences and is influenced by the organizational pattern of the spaces it links. The configuration of a path may reinforce a spatial organization by paralleling its pattern. Or the configuration may contrast with the form of the spatial organization and serve as a visual counterpoint to it. Once we are able to map out in our minds the overall configuration of the paths in a building, our orientation within the building and our understanding of its spatial layout will be made clear.



1. Linear

All paths are linear. A straight path, however, can be the primary organizing element for a series of spaces. In addition, it can be curvilinear or segmented, intersect other paths, have branches, or form a loop.

2. Radial

A radial configuration has linear paths extending from or terminating at a central, common point.

3. Spiral

A spiral configuration is a single, continuous path that originates from a central point, revolves around it, and becomes increasingly distant from it.

4. Grid

A grid configuration consists of two sets of parallel paths that intersect at regular intervals and create square or rectangular fields of space.

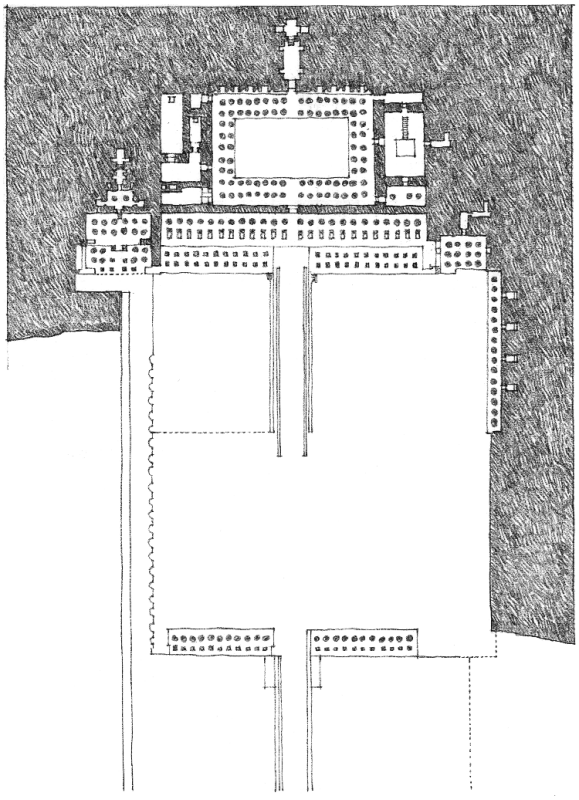
5. Network

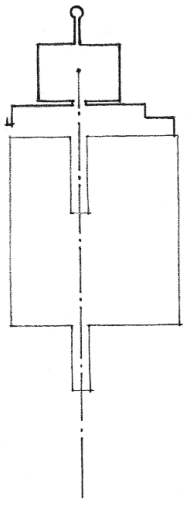
A network configuration consists of paths that connect established points in space.

6. Composite

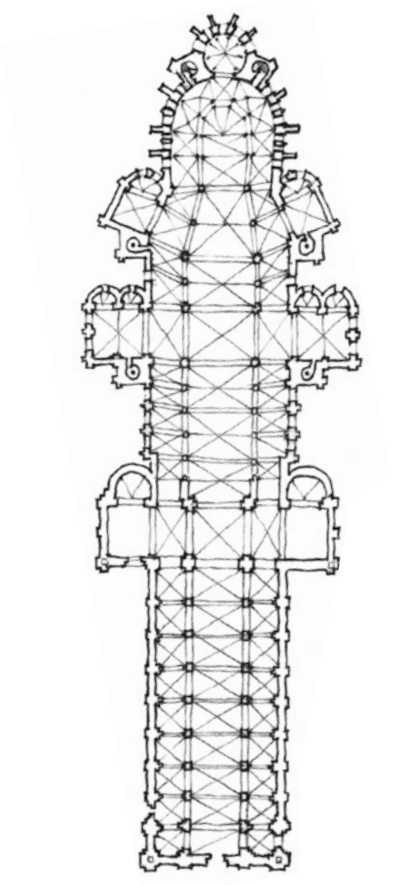
In reality, a building normally employs a combination of the preceding patterns. Important points in any pattern are centers of activity, entrances to rooms and halls, and places for vertical circulation provided by stairways, ramps, and elevators. These nodes punctuate the paths of movement through a building and provide opportunities for pause, rest, and reorientation. To avoid the creation of a disorienting maze, a hierarchical order among the paths and nodes of a building should be established by differentiating their scale, form, length, and placement.

CONFIGURATION OF THE PATH

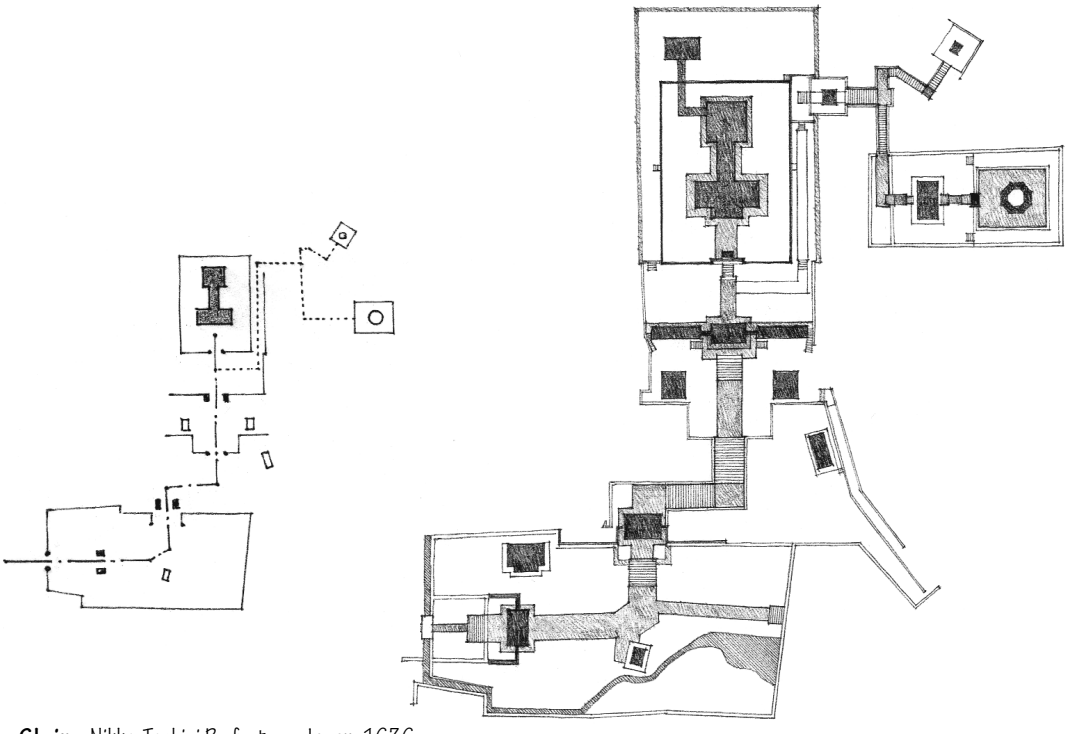




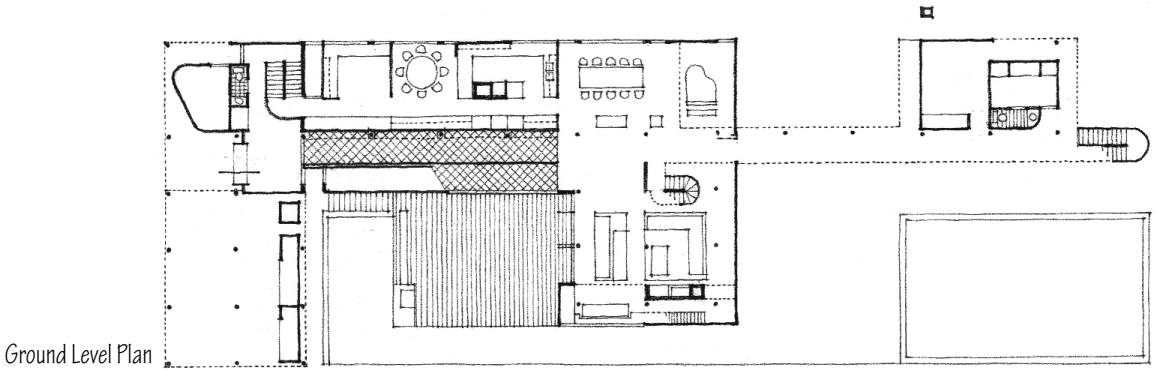
Mortuary Temple of Queen Hatshepsut, Dêr el-Bahari, Thebes, 1511–1480 B.C., Senmut

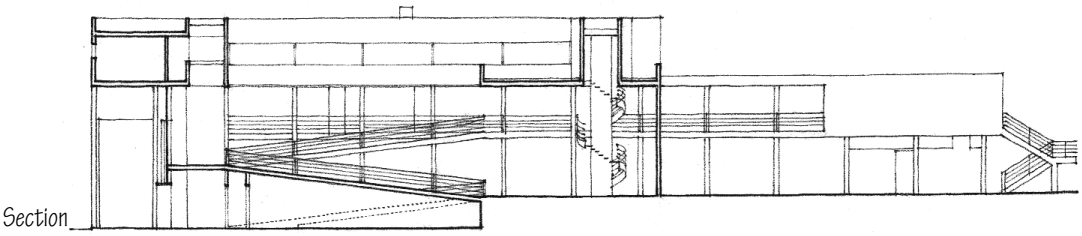


Canterbury Cathedral, England, 1070–1077



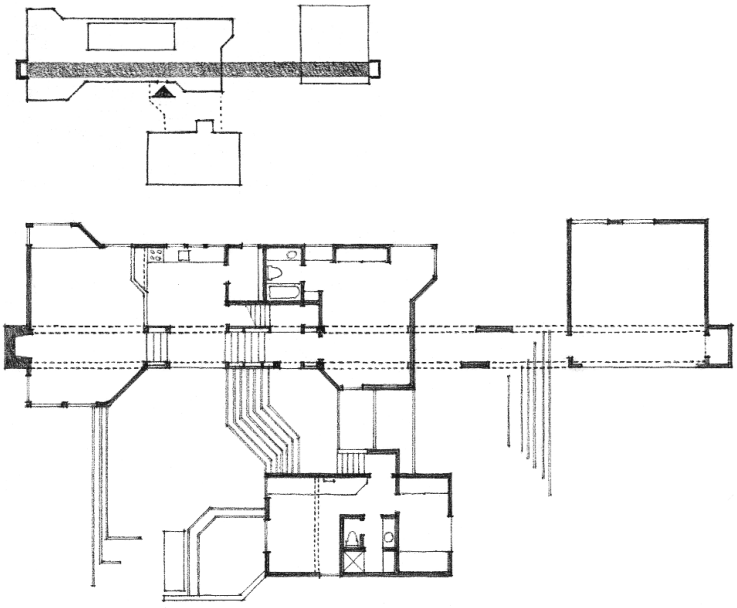
Plan of Taiyu-In Precinct of the **Toshogu Shrine**, Nikko, Tochigi Prefecture, Japan, 1636



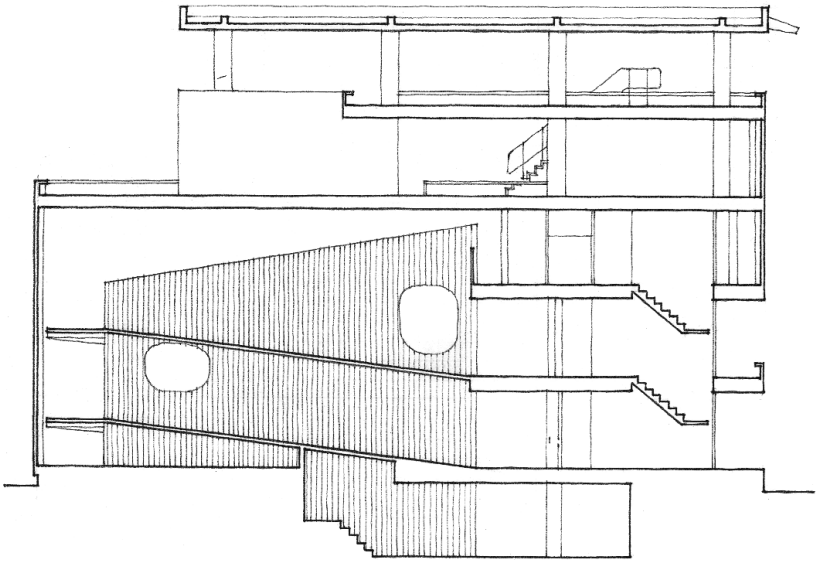


House in Old Westbury, New York, 1969–1971, Richard Meier

Linear Paths as Organizing Elements

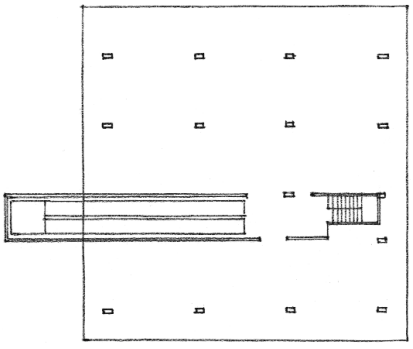


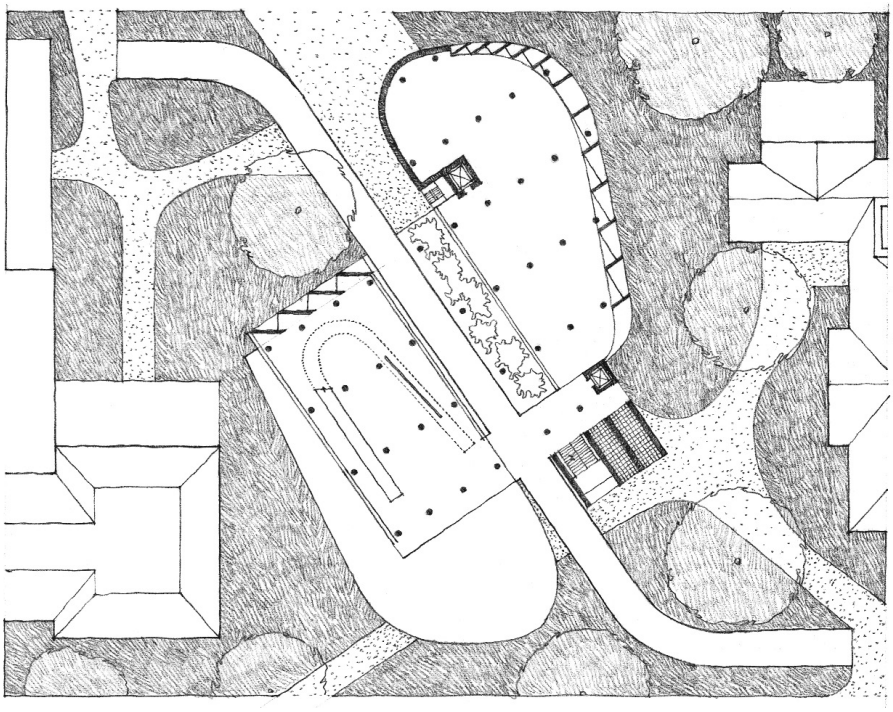
First Floor Plan, **Hines House**, Sea Ranch, California, 1966, MLTW/Moore and Turnbull



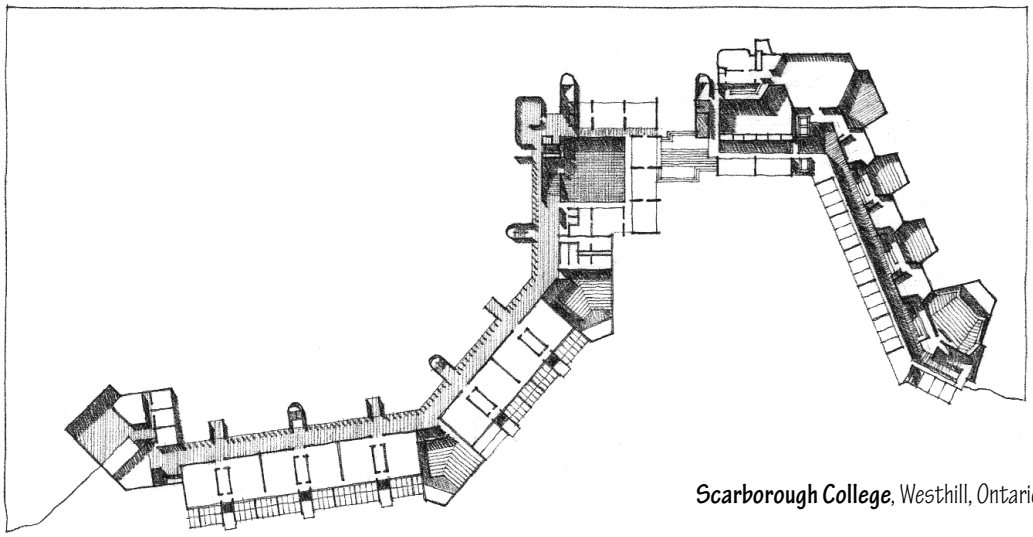
Shodhan House, Ahmedabad, India , 1956, Le Corbusier

Section through ramp and stair

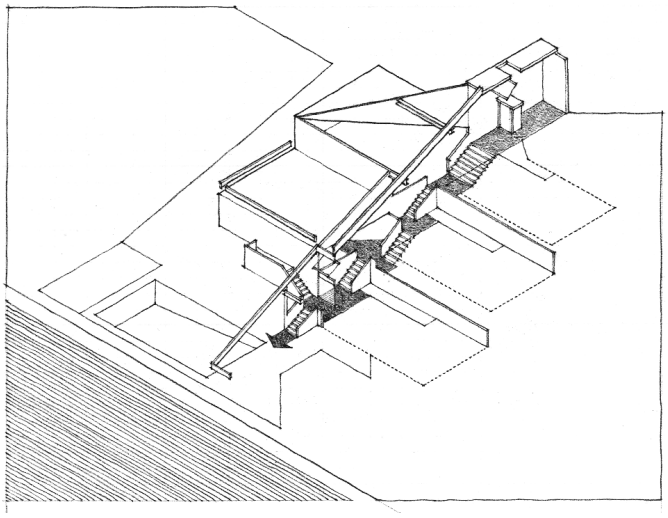




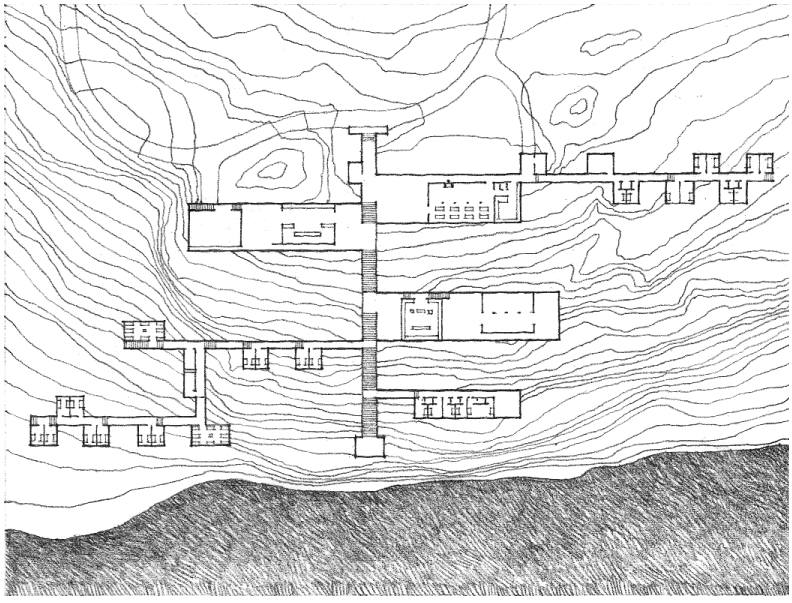
Carpenter Center for the Visual Arts, Harvard University, Cambridge, Massachusetts, 1961–1964, Le Corbusier



Scarborough College, Westhill, Ontario, 1964, John Andrews

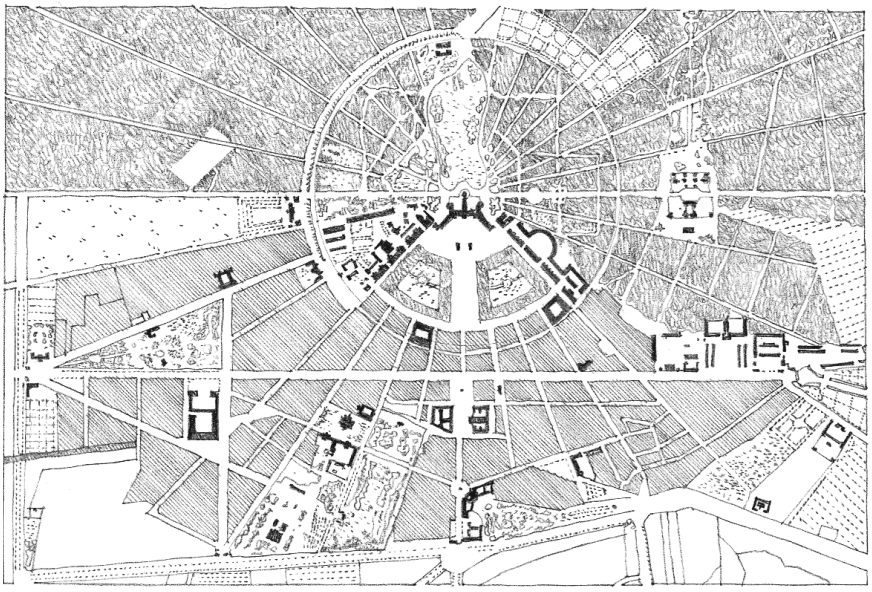


Bookstaver House, Westminster, Vermont, 1972, Peter L. Gluck

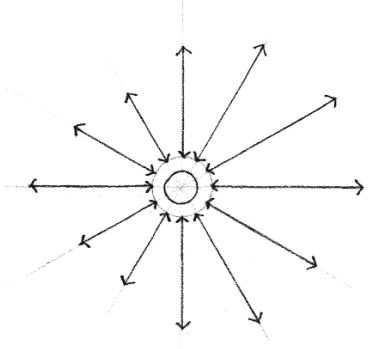


Haystack Mountain School of Arts and Crafts, Deer Isle, Maine, 1960, Edward Larrabee Barnes

CONFIGURATION OF THE PATH



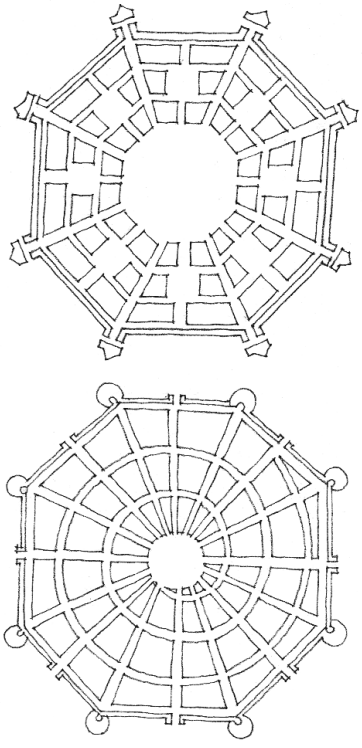
Karlsruhe, *Germany, 1834*



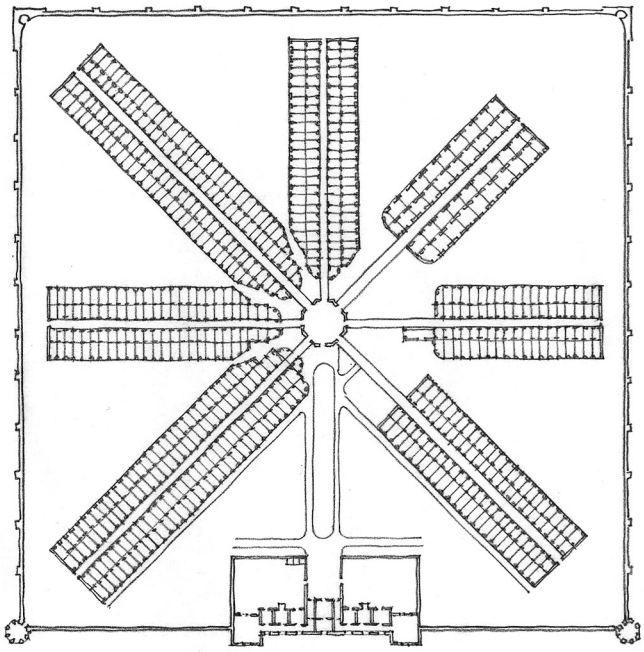
Radial Configurations

City on a Plain

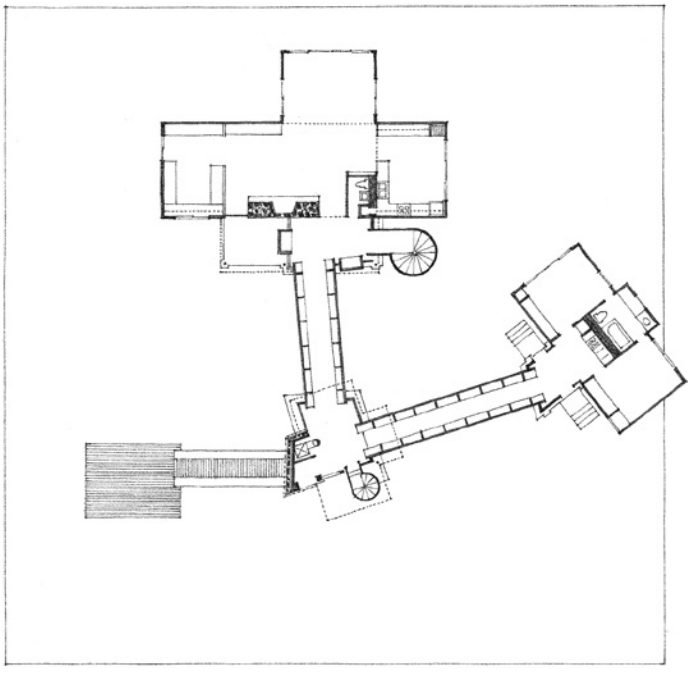
City on a Hill



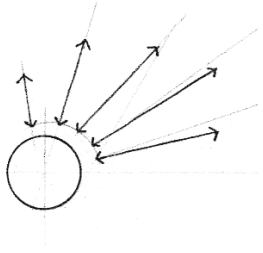
Plans of Ideal Cities, 1451–1464, *Francesco di Giorgi Martini*

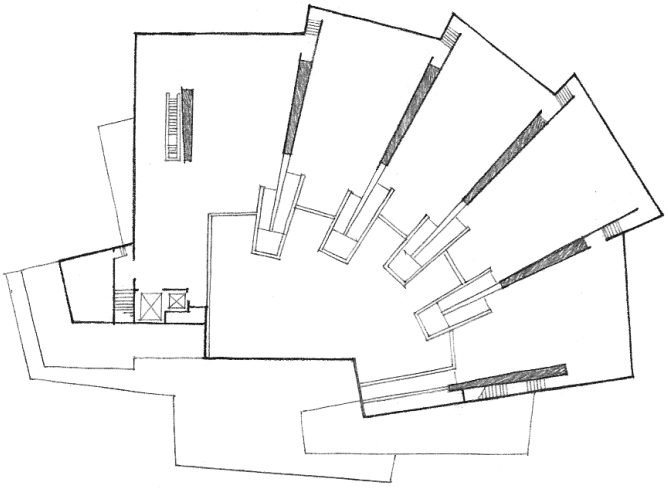


Eastern State Penitentiary, Philadelphia, 1829, John Haviland



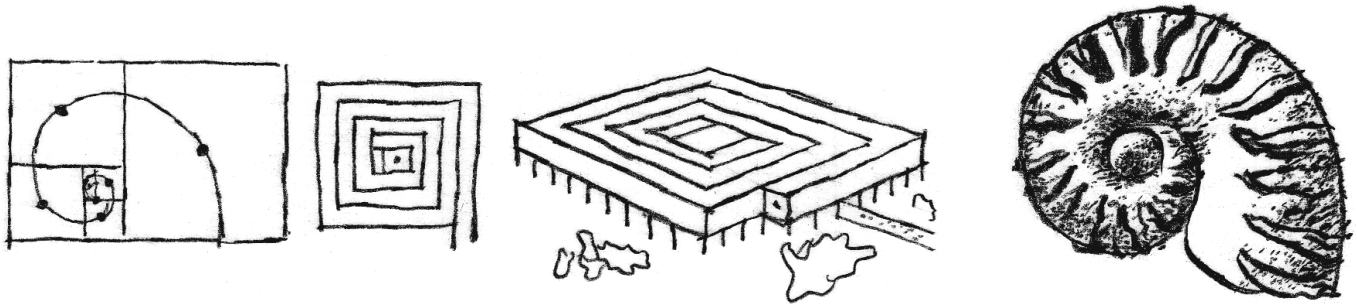
Pope House, Salisbury, Connecticut, 1974–1976, John M. Johansen

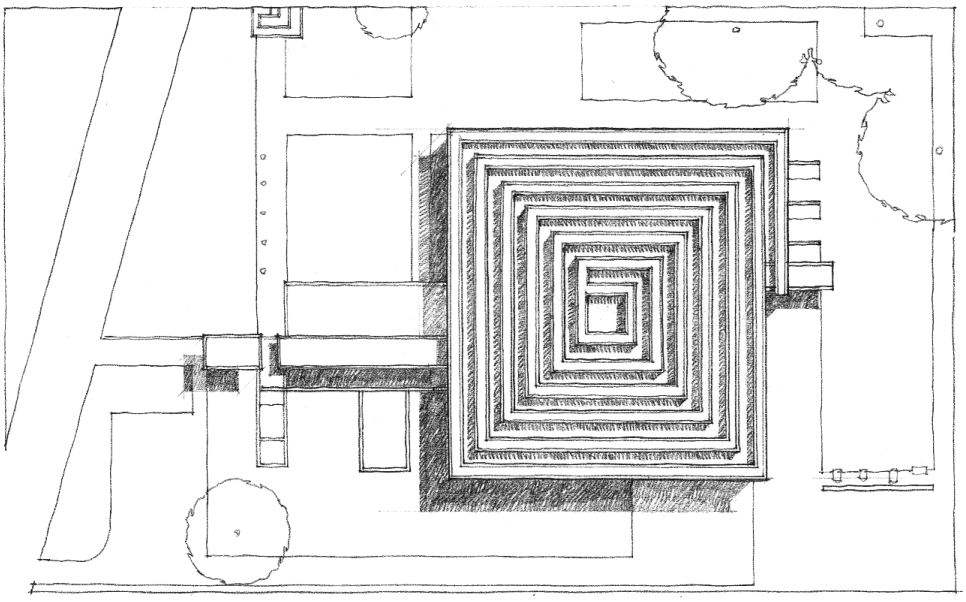




University Art Museum, University of California–Berkeley, 1971, Mario J. Ciampi and Associates

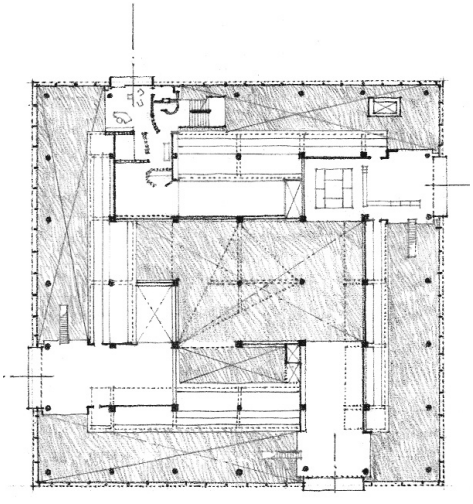
CONFIGURATION OF THE PATH



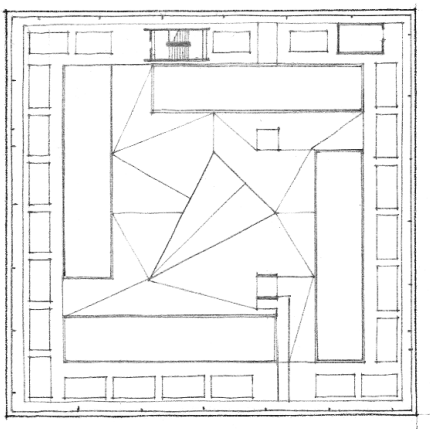


Spiral Configurations

Museum of Endless Growth (*Project*), Philippeville, Algeria, 1939, Le Corbusier

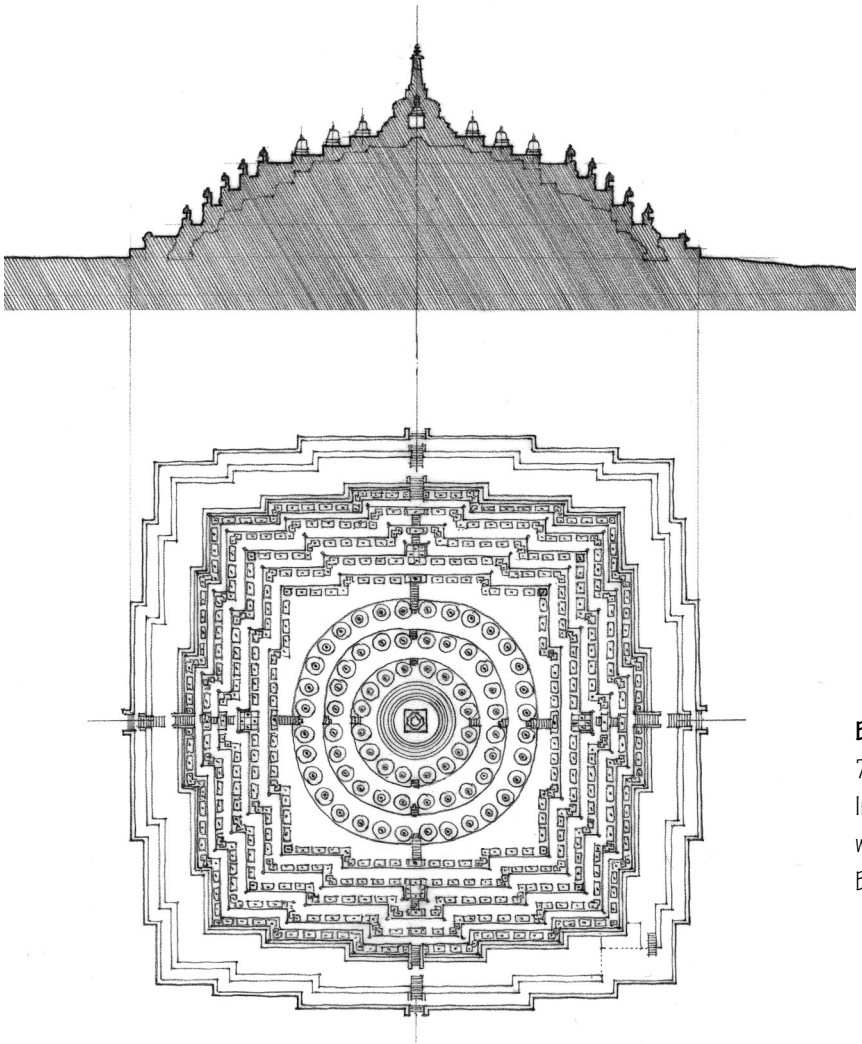


Mezzanine Plan

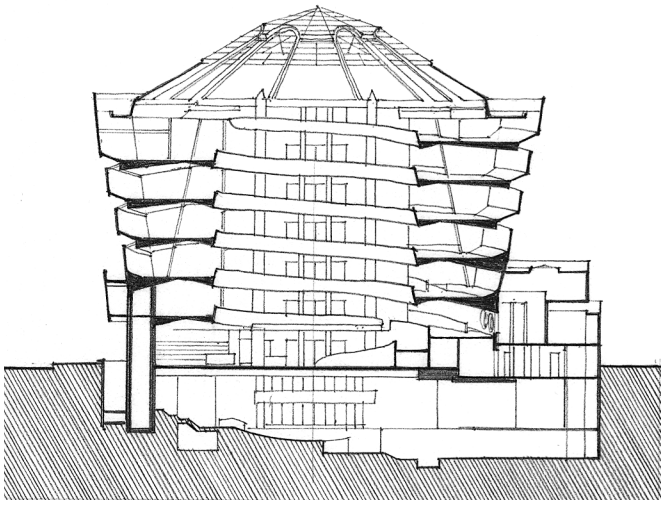


Roof Plan

Museum of Western Art, Tokyo, 1957–1959, Le Corbusier

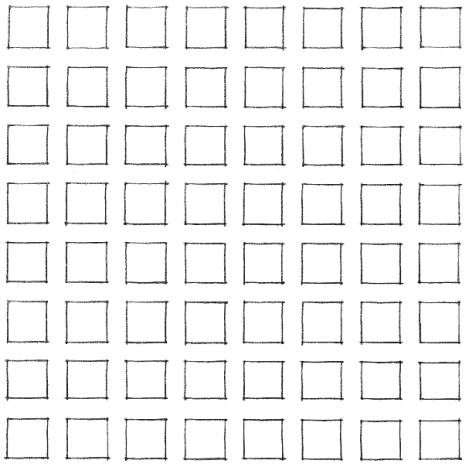


Borobodur, the Buddhist stupa monument built A.D. 750–850 in the Indonesian province of central Java. In circumambulating the monument, pilgrims passed walls ornamented with reliefs illustrating the life of Buddha and the principles of his teaching.

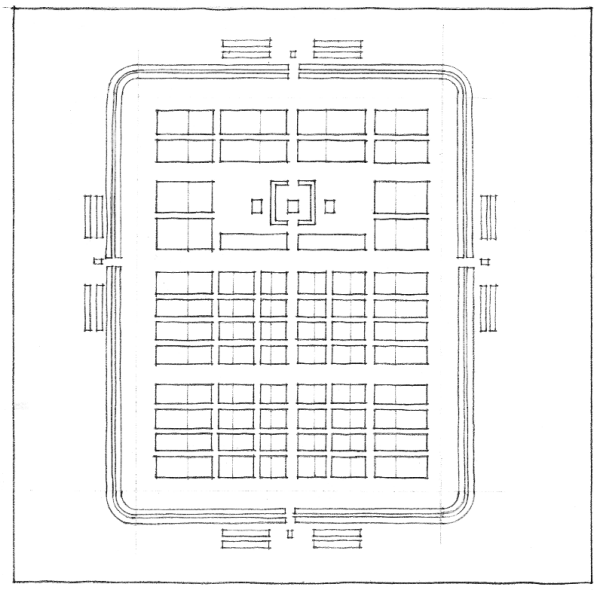


Guggenheim Museum, New York City, 1943–1959, Frank Lloyd Wright

CONFIGURATION OF THE PATH

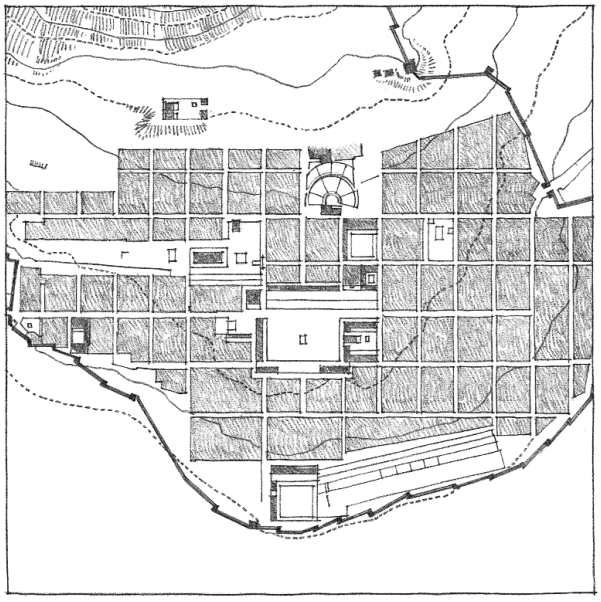


Grid Configurations

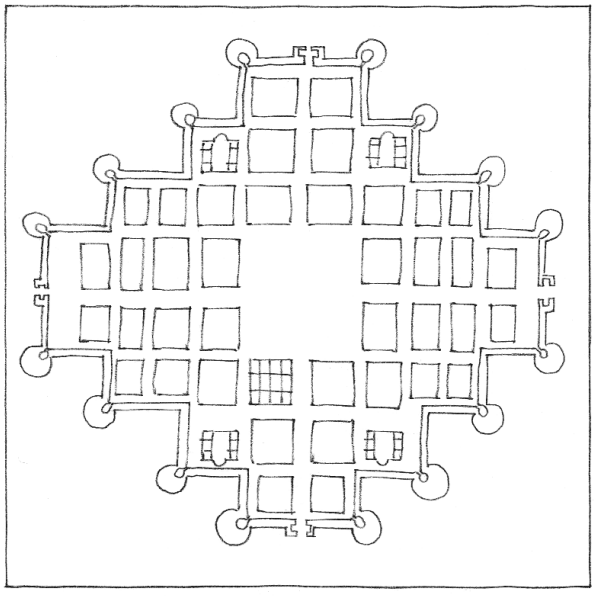


Typical layout for a **Roman Camp**, *c.* 1st century A.D.

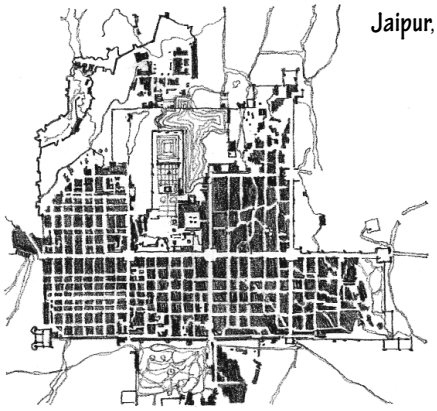
Hospital Project, Venice, 1964–1966, Le Corbusier



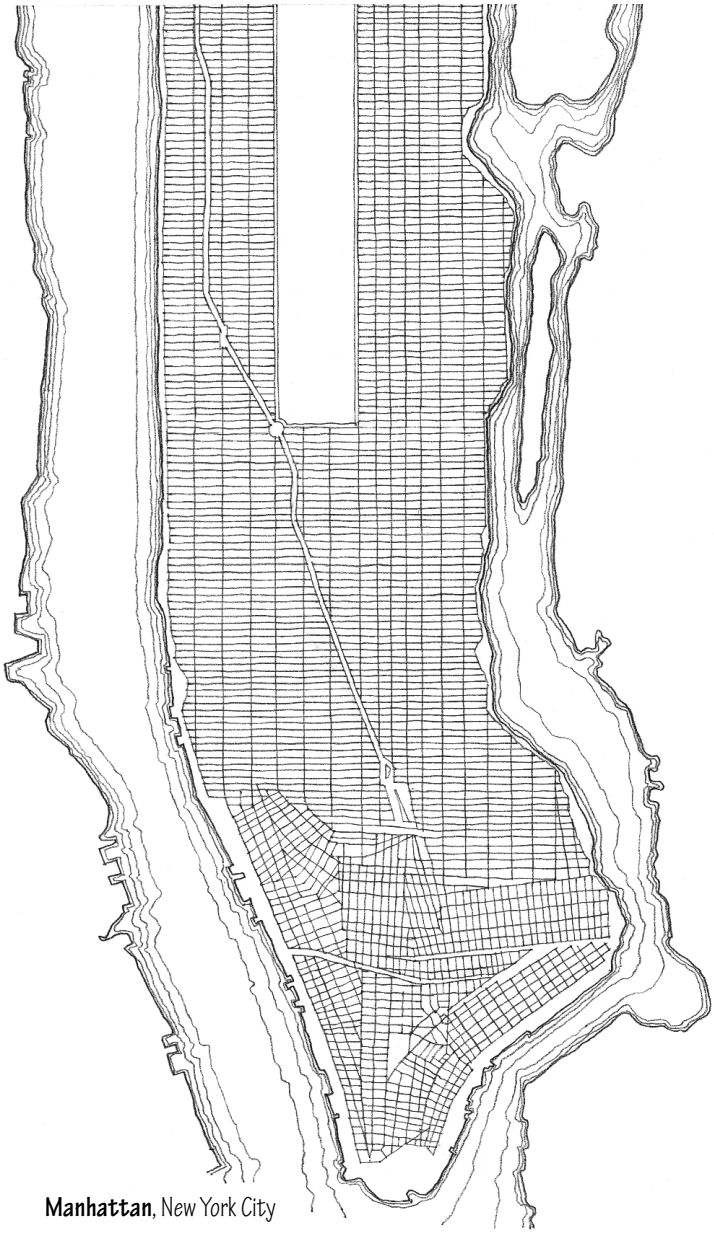
Priene, founded 4th century B.C.



Plan of an Ideal City, 1451–1464, Frances di Giorgio Martini

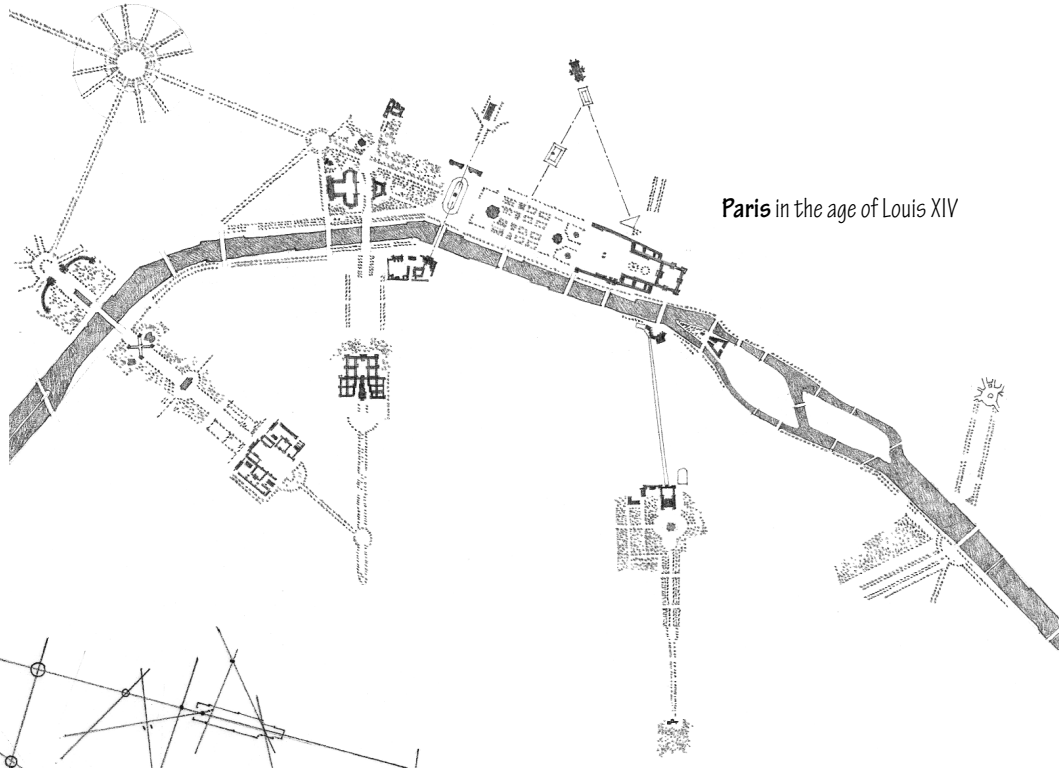


Jaipur, India, 1728



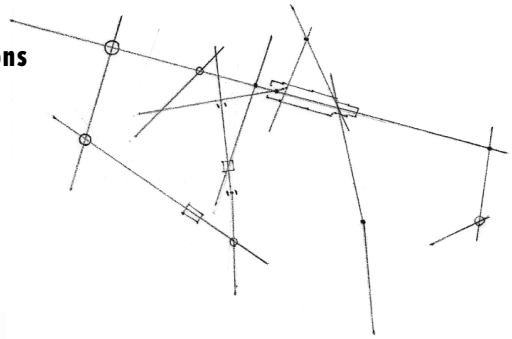
Manhattan, New York City

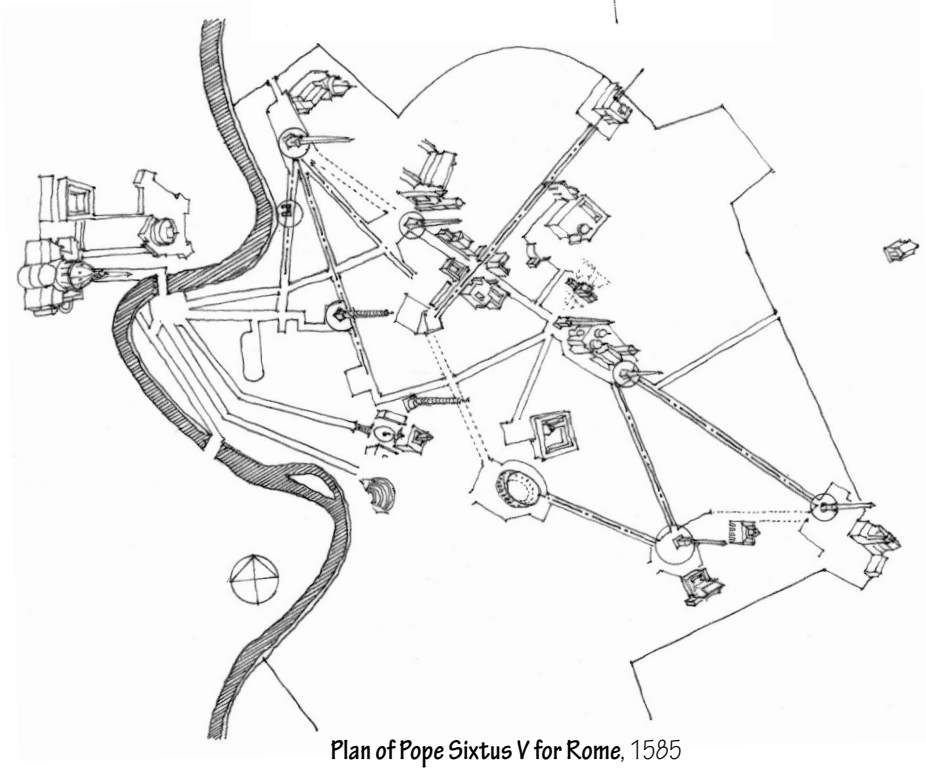
CONFIGURATION OF THE PATH



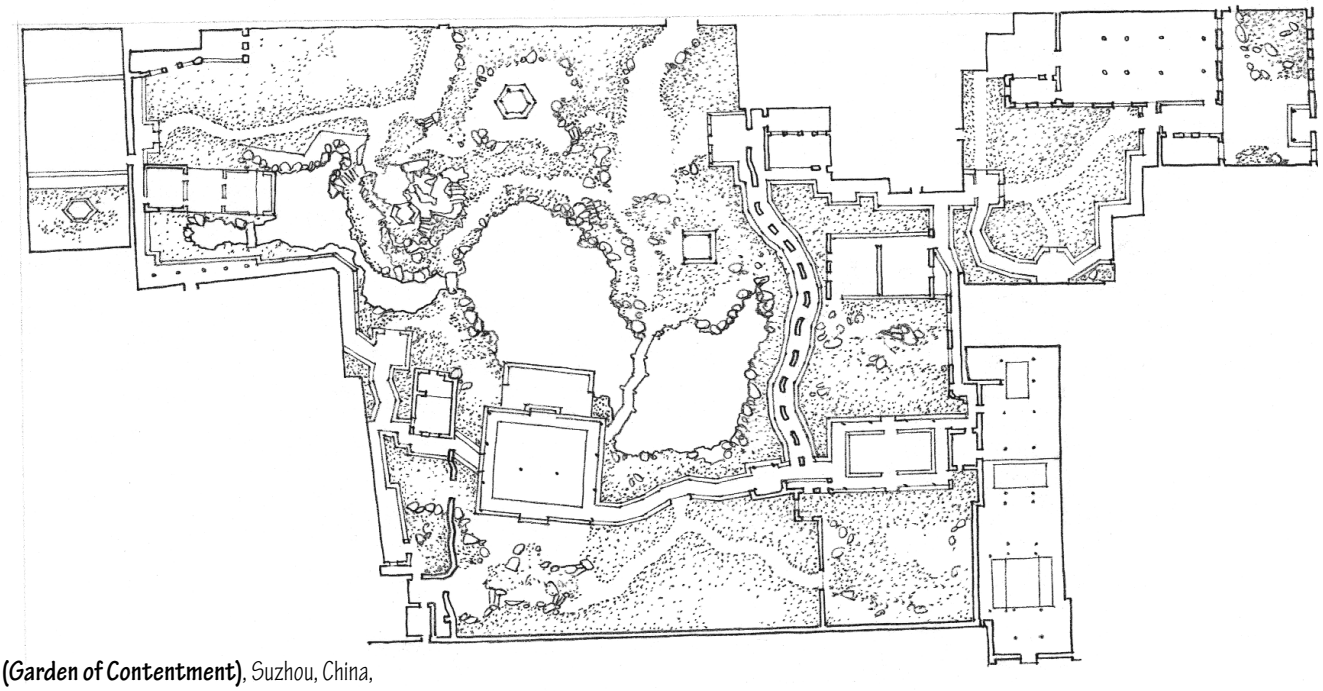
Paris in the age of Louis XIV

Network Configurations

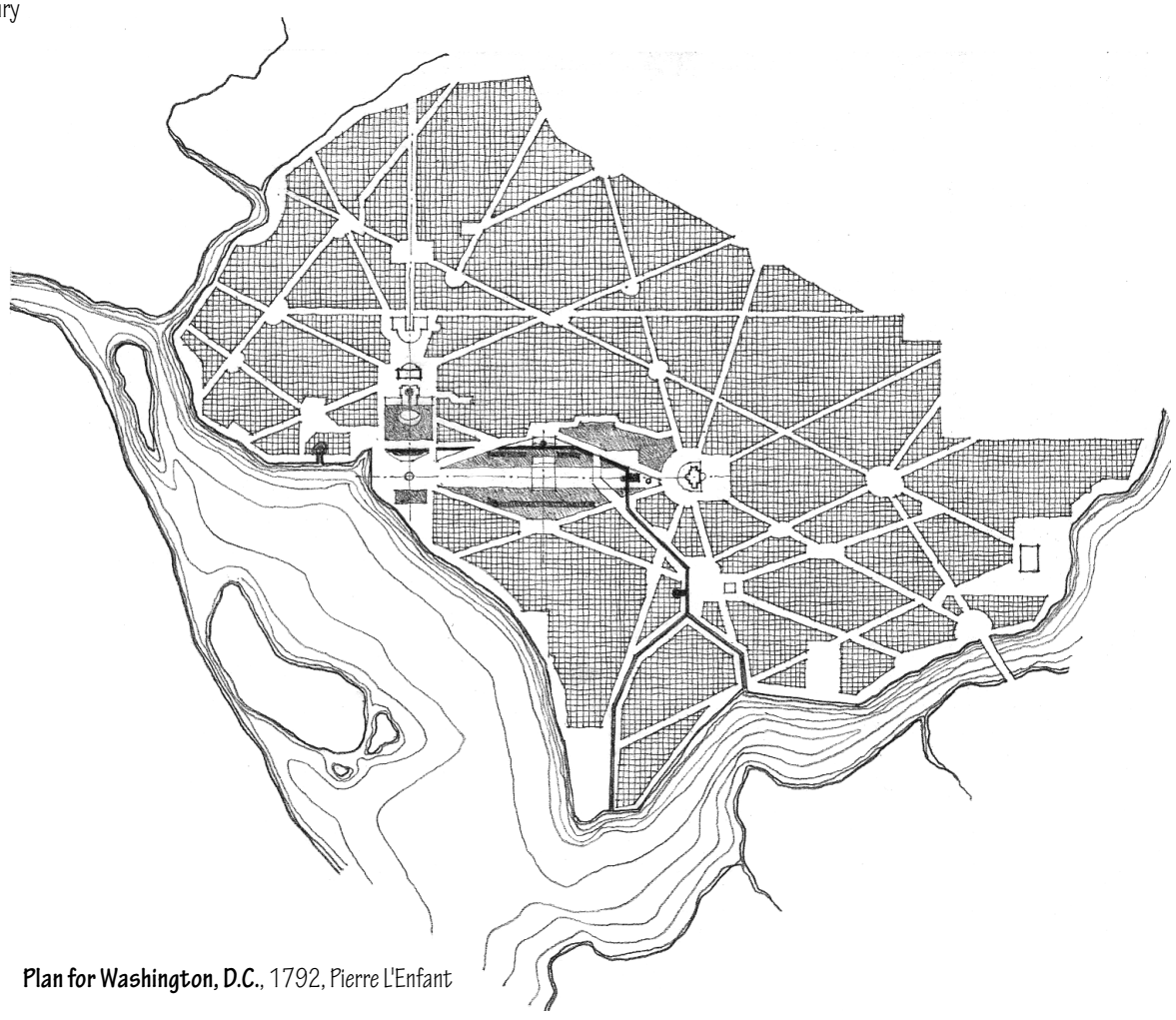




Plan of Pope Sixtus V for Rome, 1585



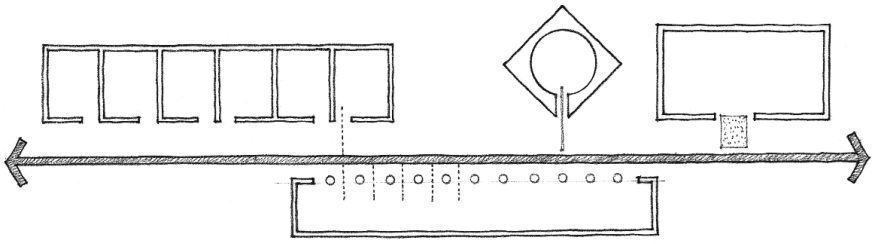
Yi Yuan (*Garden of Contentment*), Suzhou, China, Qing Dynasty, 19th century



Plan for Washington, D.C., 1792, Pierre L'Enfant

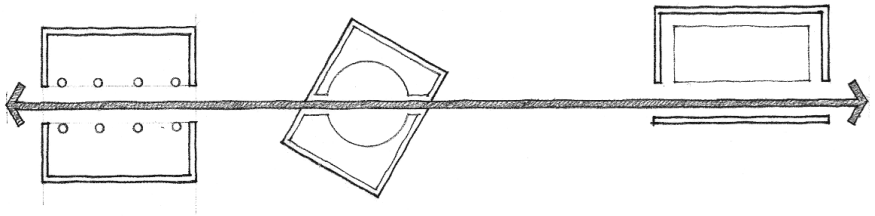
PATH–SPACE RELATIONSHIPS

Paths may be related to the spaces they link in the following ways. They may:



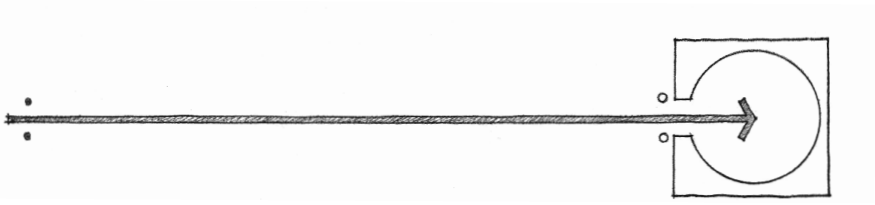
Pass by Spaces

- The integrity of each space is maintained.
- The configuration of the path is flexible.
- Mediating spaces can be used to link the path with the spaces.



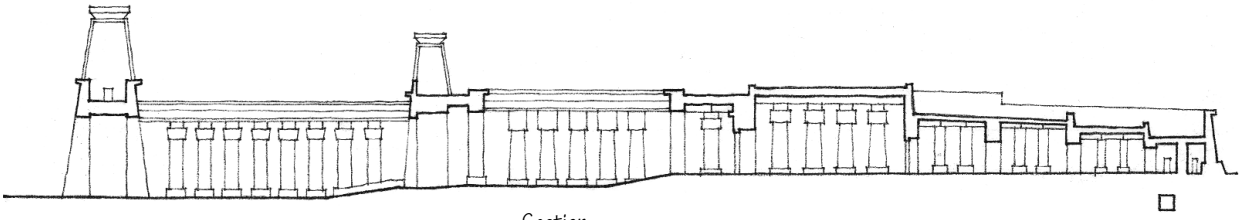
Pass through Spaces

- The path may pass though a space axially, obliquely, or along its edge.
- In cutting through a space, the path creates patterns of rest and movement within it.

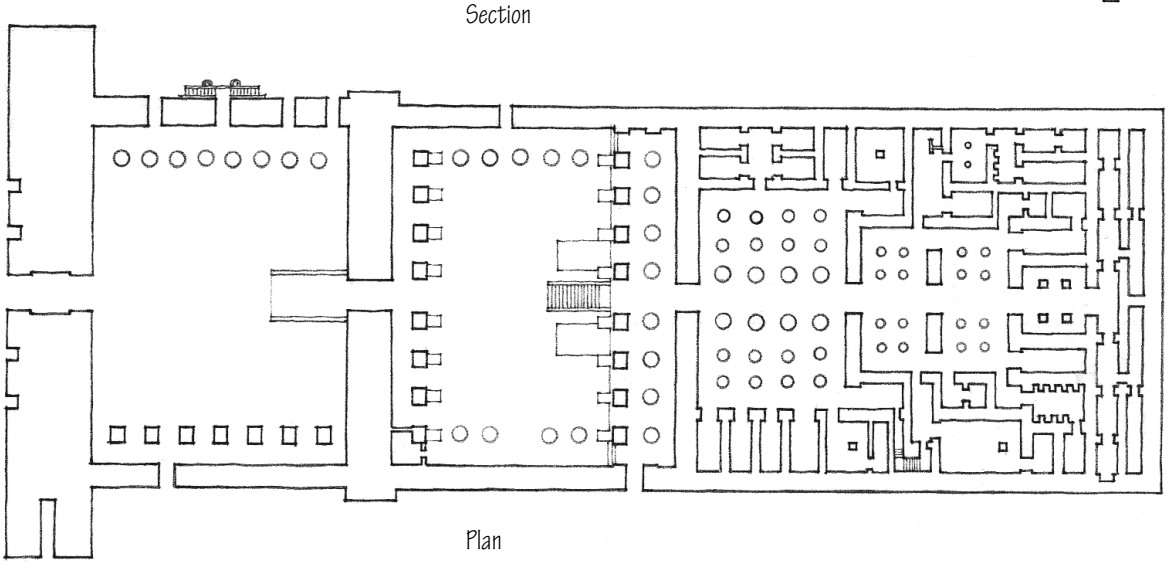


Terminate in a Space

- The location of the space establishes the path.
- This path-space relationship is used to approach and enter functionally or symbolically important spaces.

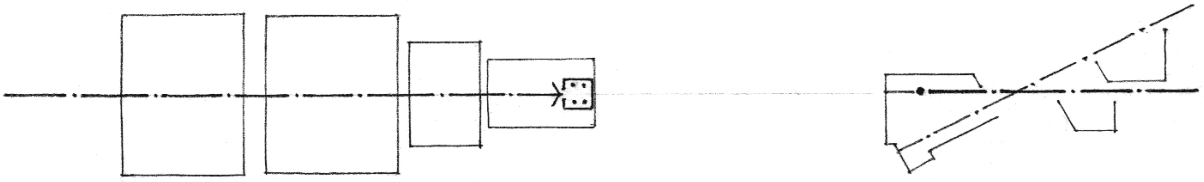


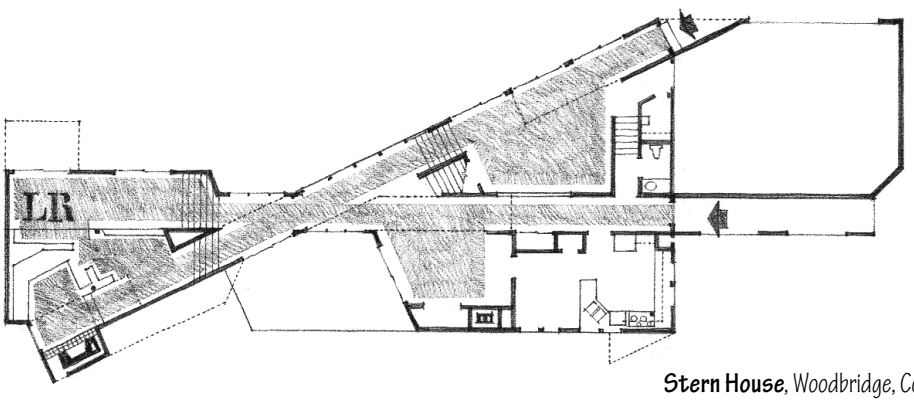
Section



Plan

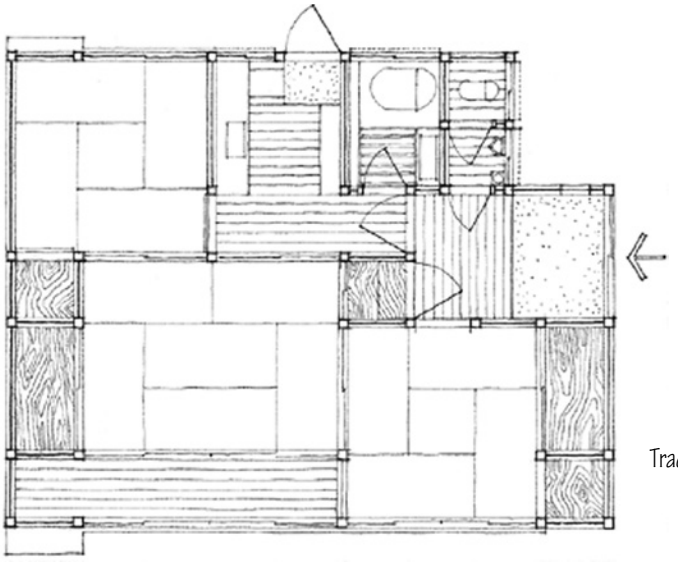
Mortuary Temple of Rameses III, Medinet-Habu, 1198 B.C.

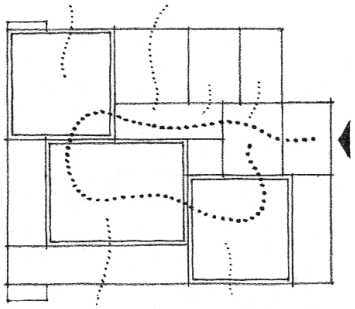




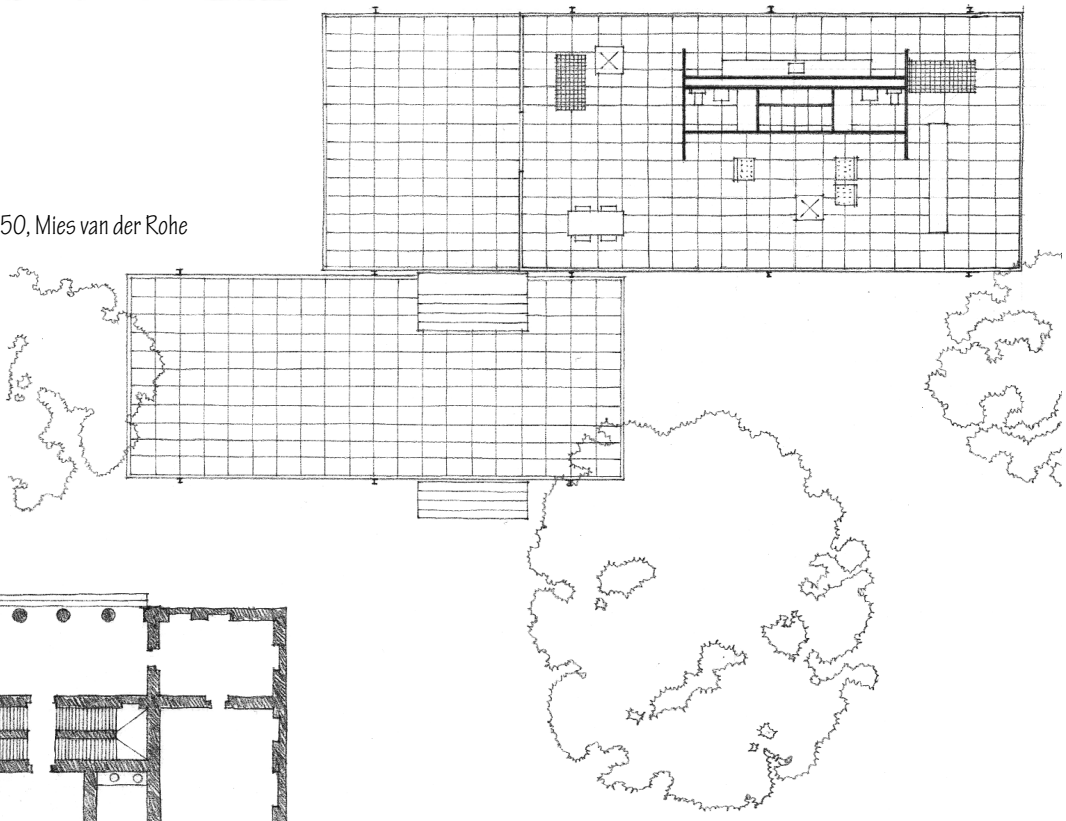
Stern House, Woodbridge, Connecticut, 1970, Charles Moore Associates

PATH–SPACE RELATIONSHIPS

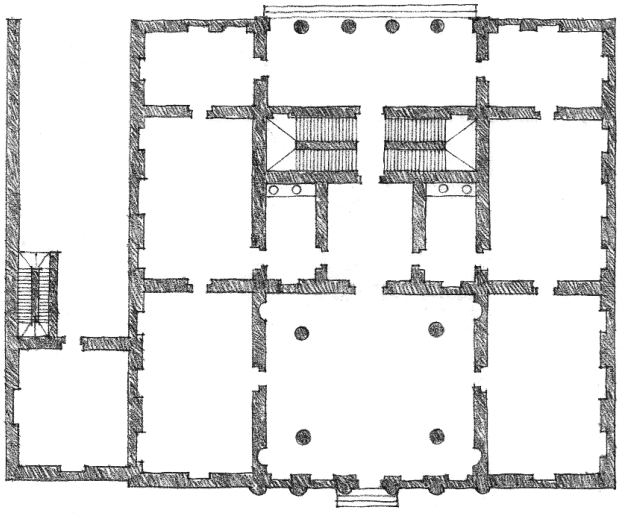




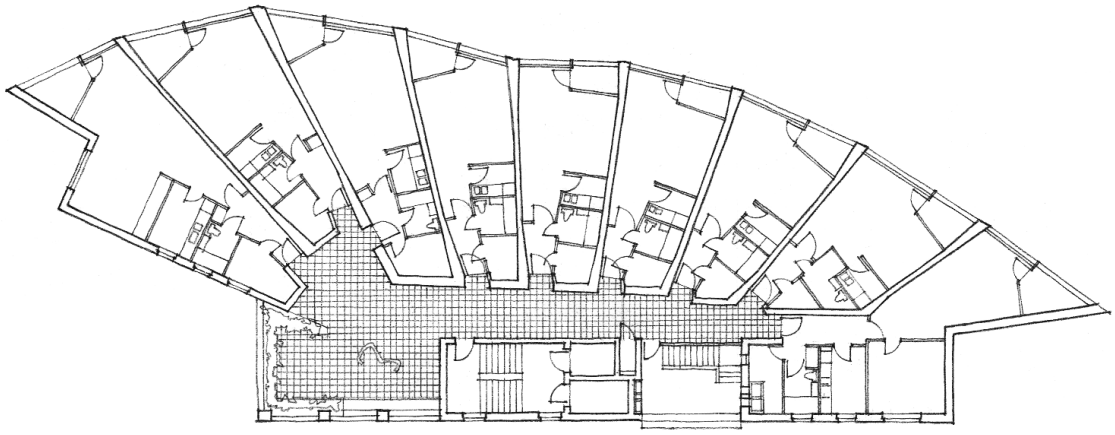
Traditional Japanese House



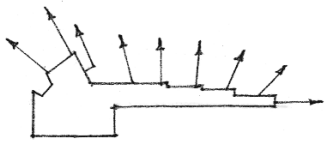
Farnsworth House, Plano, Illinois, 1950, Mies van der Rohe

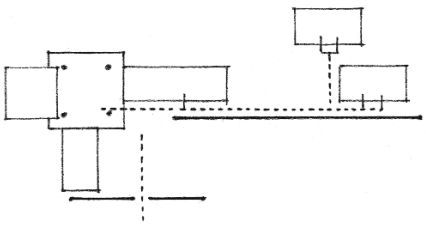


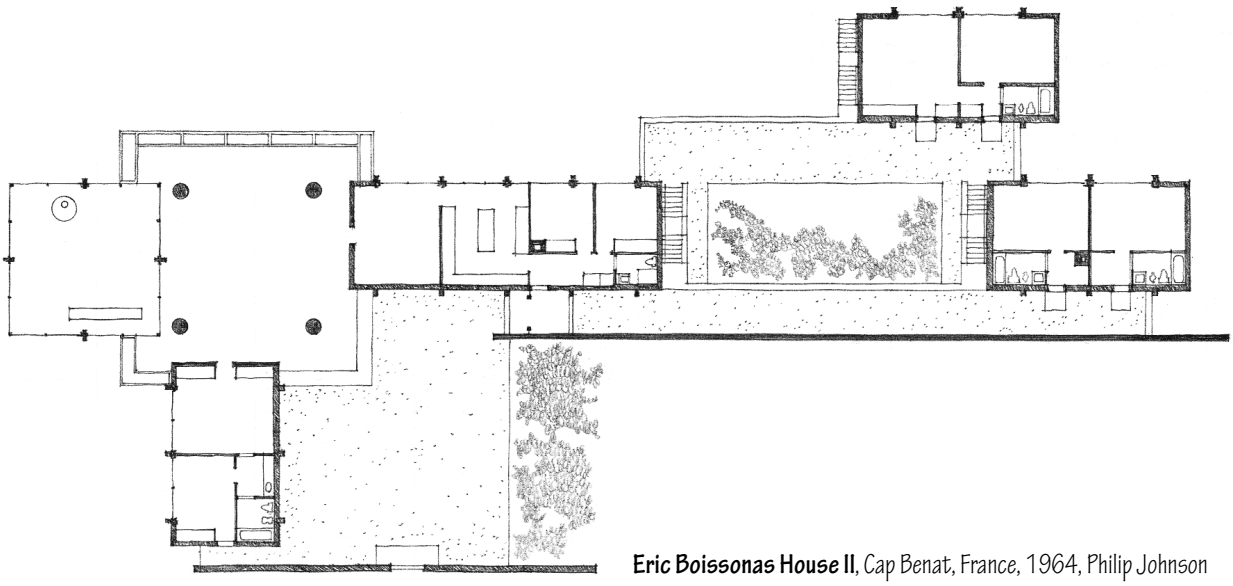
Palazzo Antonini, Udine, Italy, 1556, Andrea Palladio



Neur Vahr Apartment Building, Bremen, Germany, 1958–1962, Alvar Aalto







Eric Boissonas House II, Cap Benat, France, 1964, Philip Johnson

FORM OF THE CIRCULATION SPACE

A vaulted staircase,
after a drawing by William R. Ware

Spaces for movement form an integral part of any building organization and occupy a significant amount of the volume of a building. If considered merely as functional linking devices, then circulation paths would be endless, corridor-like spaces. The form and scale of a circulation space, however, should accommodate the movement of people as they promenade, pause, rest, or take in a view along a path.

The form of a circulation space varies according to how:

- Its boundaries are defined;
- Its form relates to the form of the spaces it links;
- Its qualities of scale, proportion, light, and view are articulated;
- Entrances open onto it; and
- It handles changes in level with stairs and ramps.

A circulation space may be:

Enclosed

forming a public galleria or private corridor that relates to the spaces it links though entrances in a wall plane;

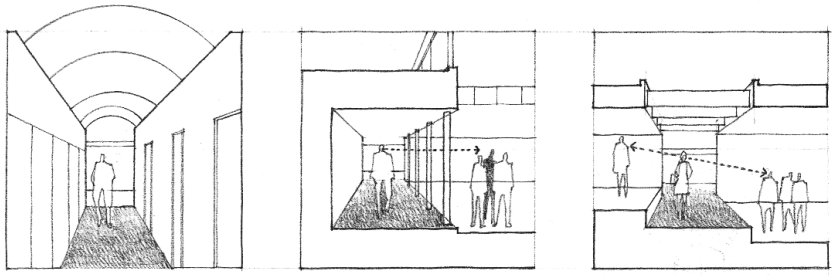
Open on One Side

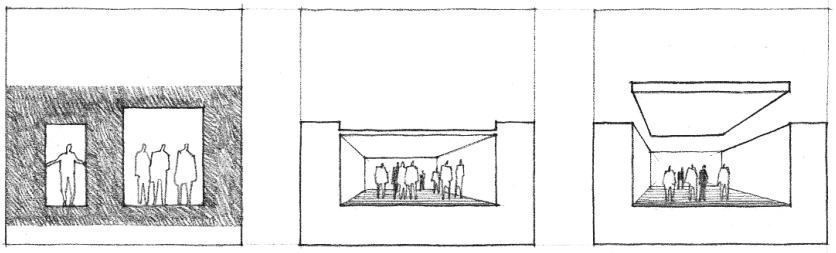
forming a balcony or gallery that provides visual and spatial continuity with the spaces it links;

Open on Both Sides

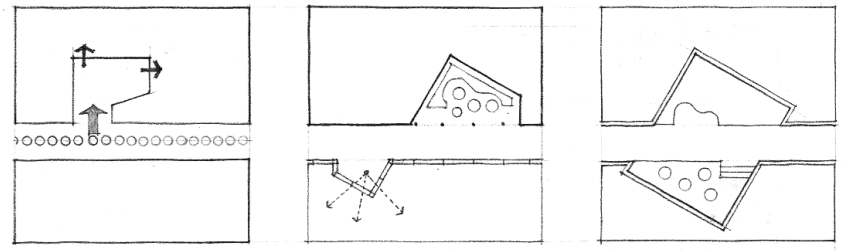
forming a colonnaded passageway that becomes a physical extension of the space it passes through.

The width and height of a circulation space should be proportionate with the type and amount of movement it must handle. A distinction in scale should be established between a public promenade, a more private hall, and a service corridor.

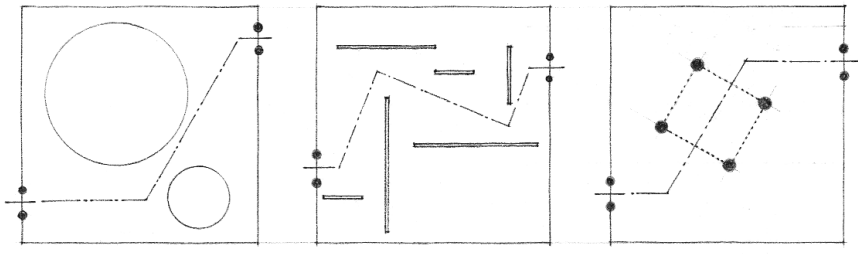




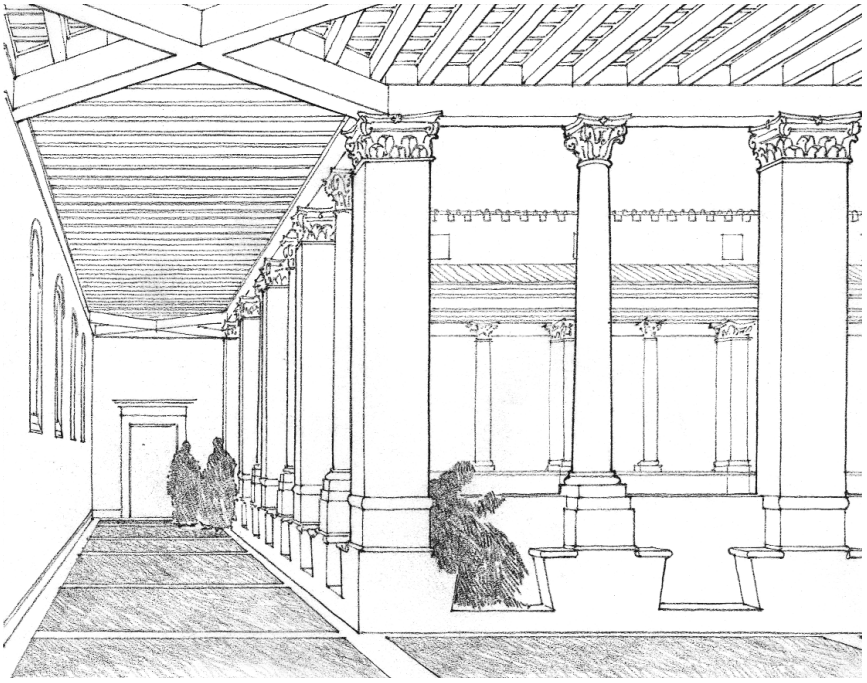
A narrow, enclosed path naturally encourages forward motion. To accommodate more traffic as well as to create spaces for pausing, resting, or viewing, sections of a path can be widened. The path can also be enlarged by merging with the spaces it passes through.



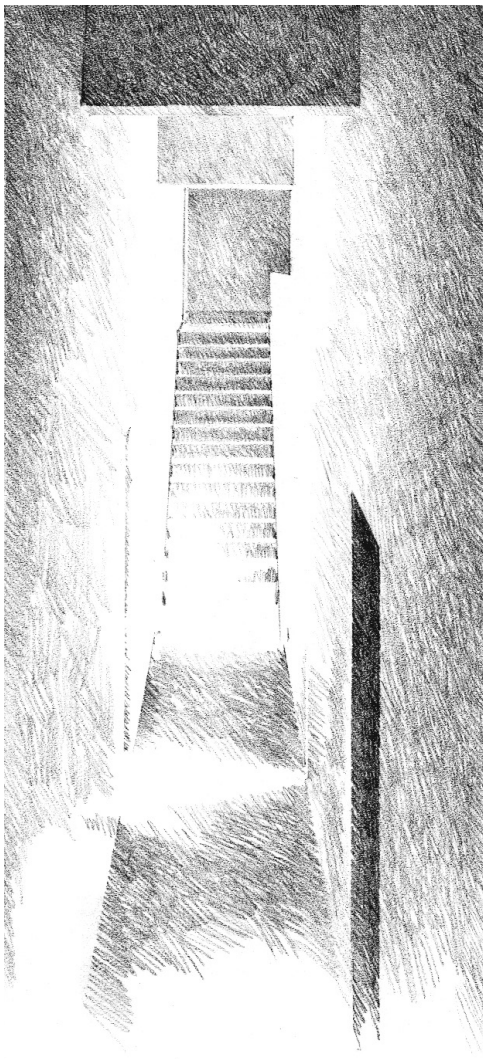
Within a large space, a path can be random, without form or definition, and be determined by the activities and arrangement of furnishings within the space.



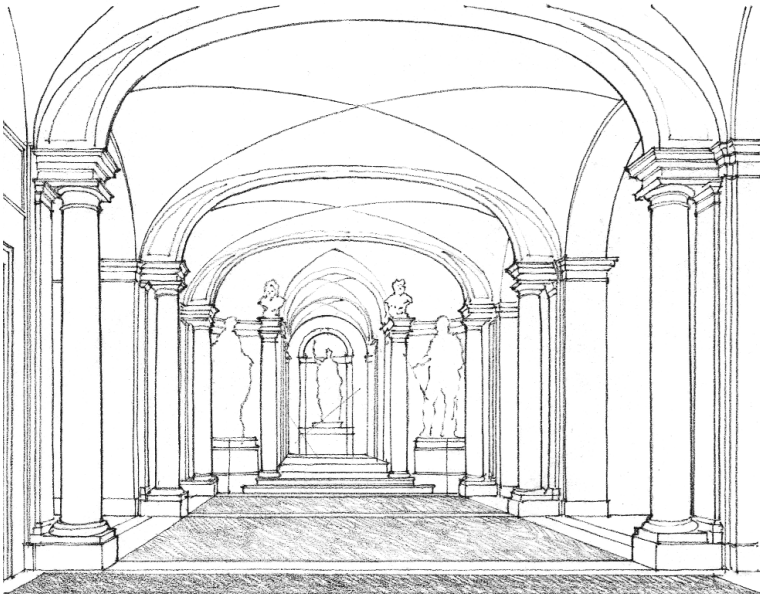
FORM OF THE CIRCULATION SPACE



Cloister, **St. Maria della Pace**, Rome, 1500–1504, Donato Bramante

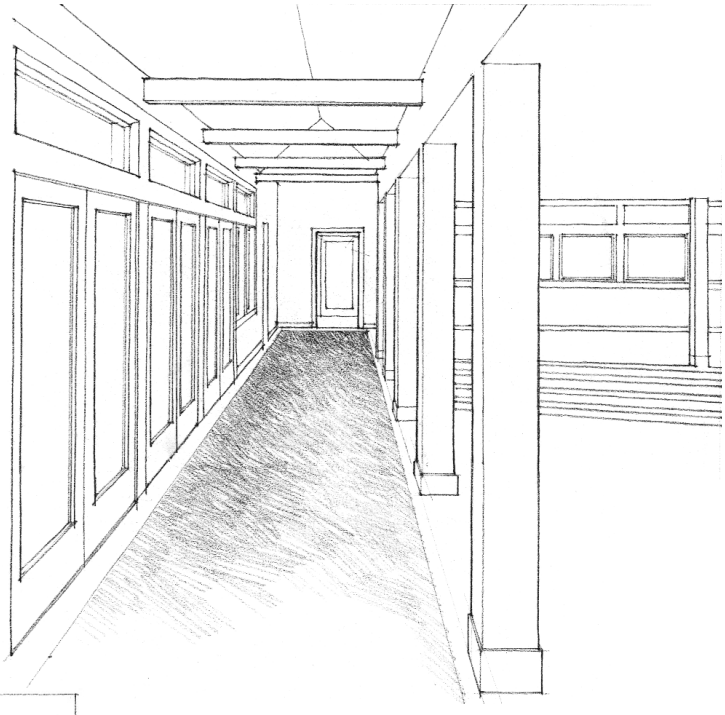


Hallway of **Okusu Residence**, Todoroki, Tokyo, 1976–1978, Tadao Ando

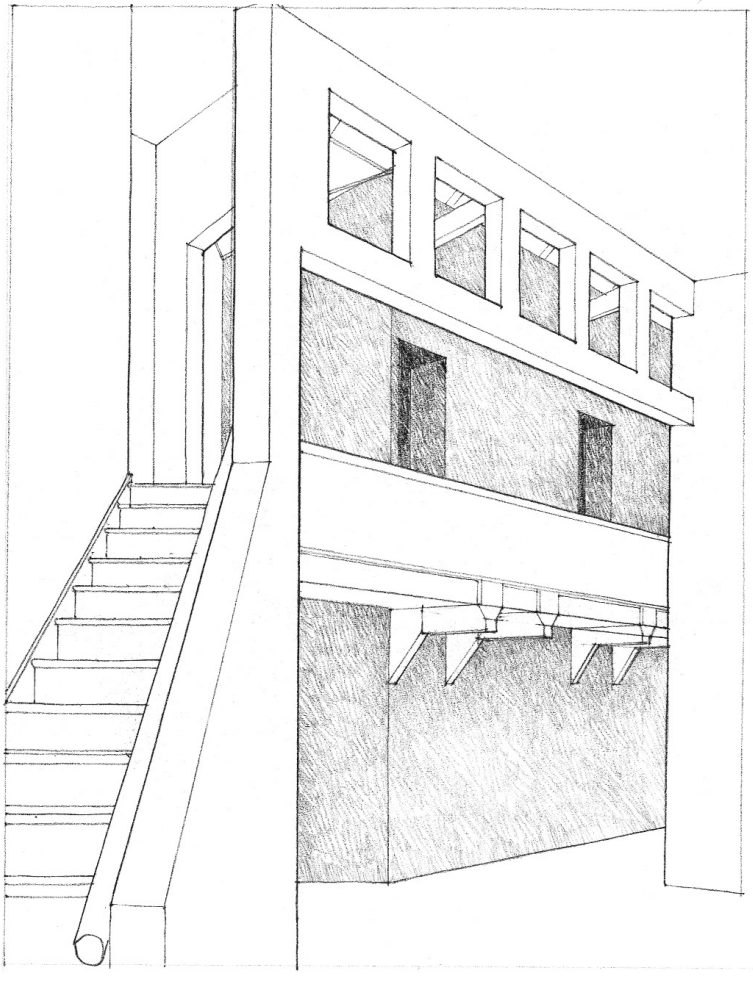


Vestibule of a Renaissance palace

Examples of various forms of spaces used for movement through a building.

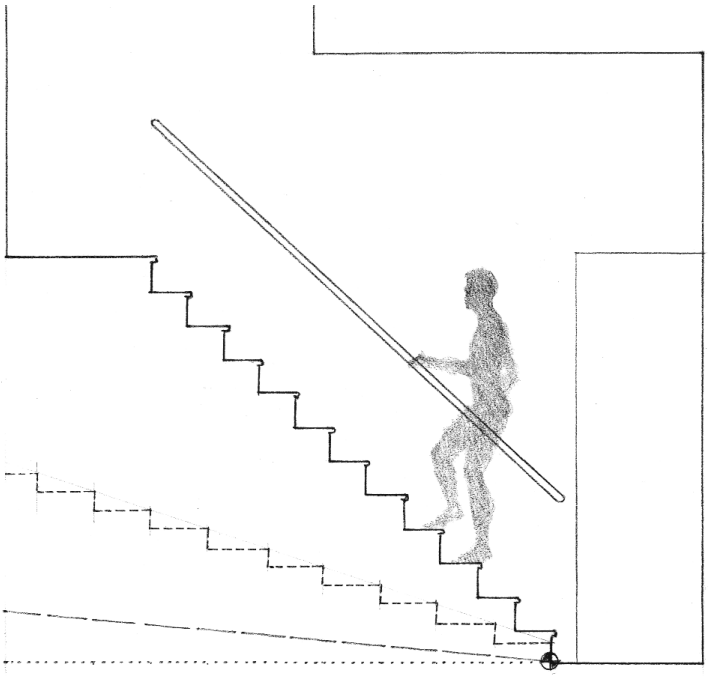


A hall opening through a colonnade onto an interior space and through a series of French doors onto an exterior courtyard

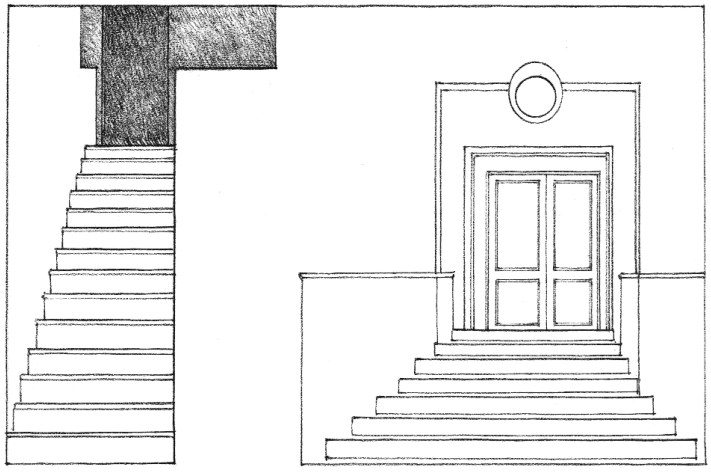


Raised hall, **Residence in Morris County**, New Jersey, 1971, MLTW

STAIRWAYS

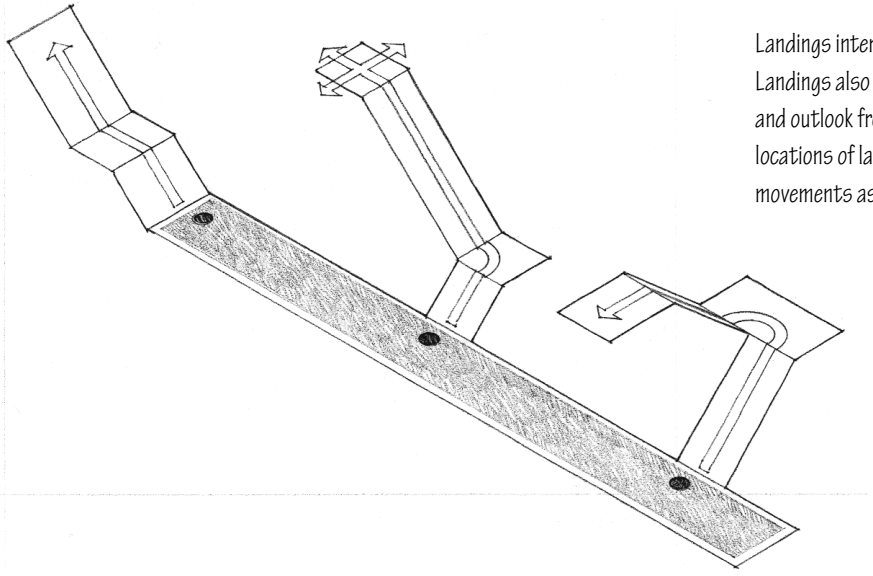


Stairs and stairways provide for our vertical movement between the levels of a building or outdoor space. The slope of a stairway, determined by the dimensions of its risers and treads, should be proportioned to fit our body movement and capability. If steep, a stair can make ascent physically tiring as well as psychologically forbidding, and can make descent precarious. If shallow, a stair must have treads deep enough to fit our stride.



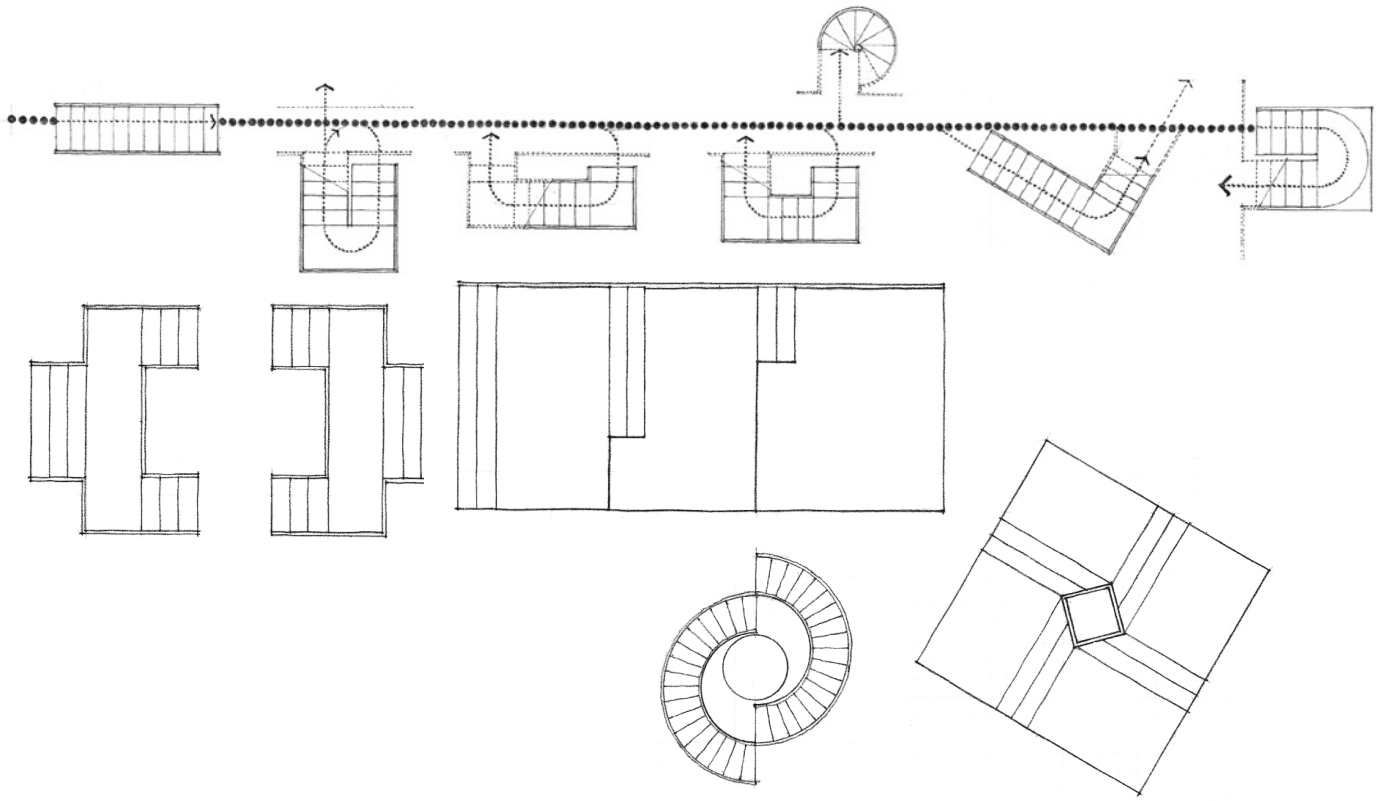
A stairway should be wide enough to comfortably accommodate our passage as well as any furnishings and equipment that must be moved up or down the steps. The width of a stairway also provides a visual clue to the public or private nature of the stairway. Wide, shallow steps can serve as an invitation, while a narrow, steep stairway can lead to more private places.

While the act of traversing up a stairway may convey privacy, aloofness, or detachment, the process of going down can imply moving toward secure, protected, or stable ground.



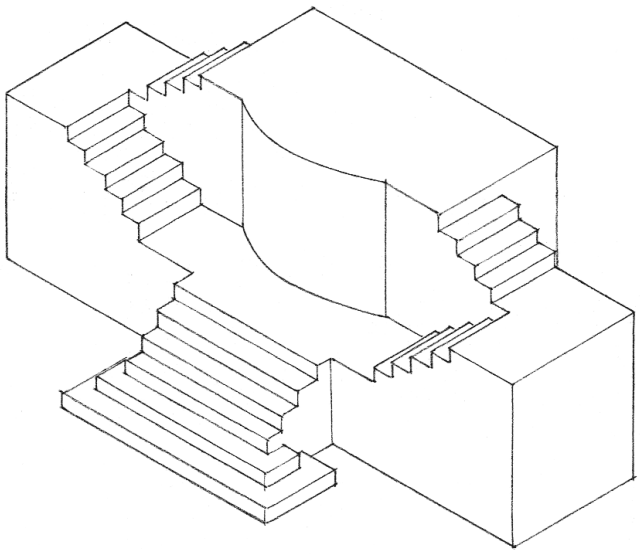
Landings interrupt the run of a stair and enable it to change direction. Landings also provide opportunities for rest and possibilities for access and outlook from the stairway. Together with the pitch of a stair, the locations of landings determine the rhythm and choreography of our movements as we ascend or descend its steps.

Stairs, in accommodating a change in level, can reinforce the path of movement, interrupt it, accommodate a change in its course, or terminate it prior to entering a major space.

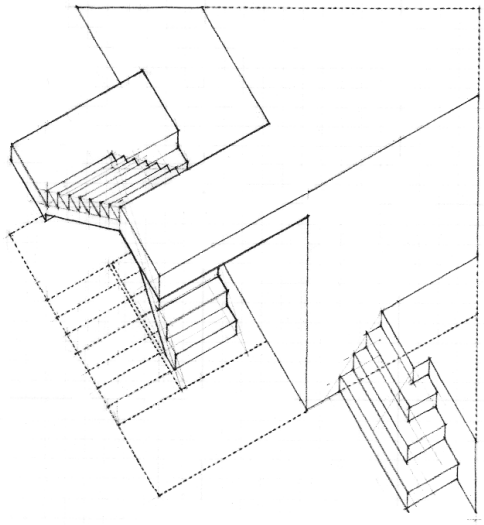


The configuration of a stairway determines the direction of our path as we ascend or descend its steps. There are several basic ways in which to configure the runs of a stairway.

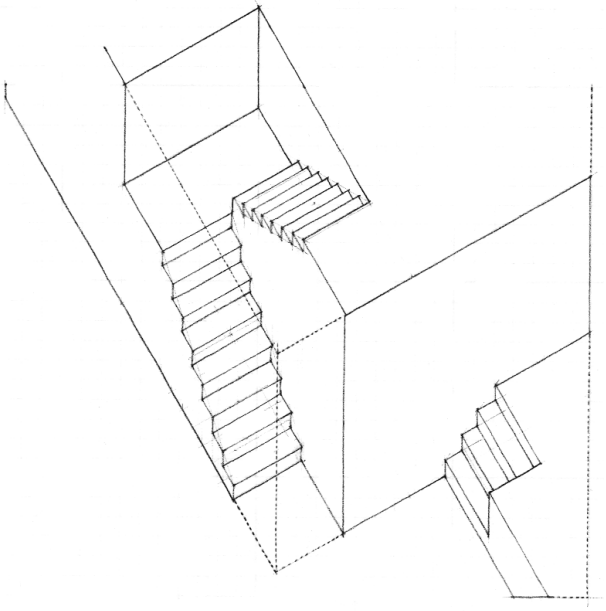
- Straight-run stair
- L-shaped stair
- U-shaped stair
- Circular stair
- Spiral stair

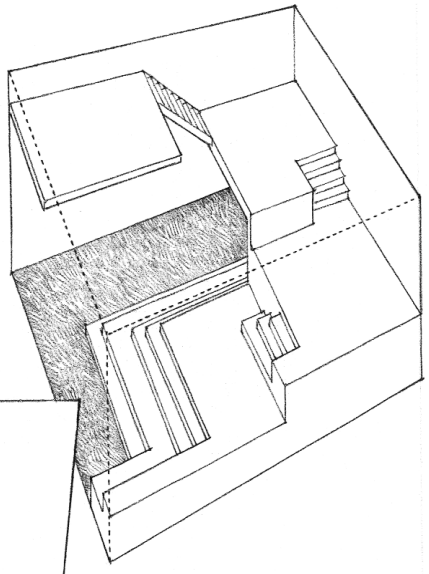


STAIRWAYS

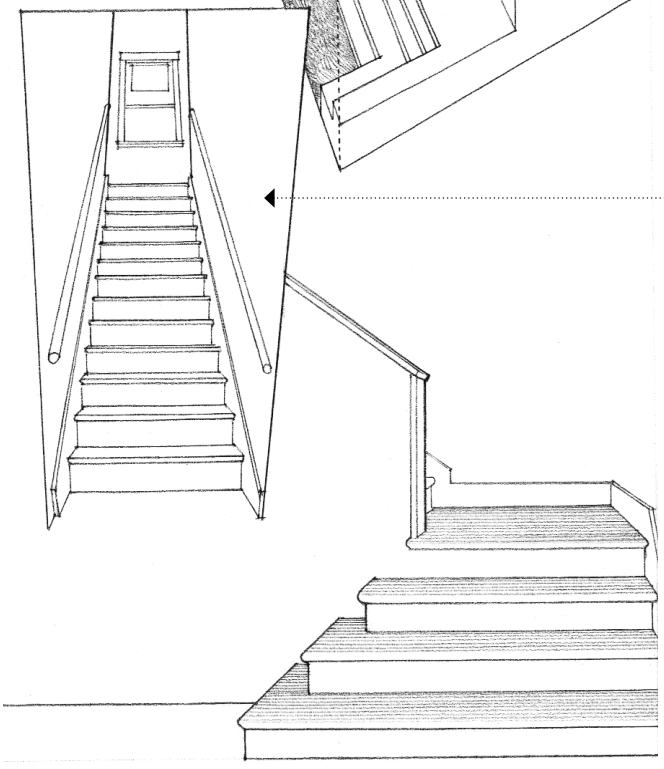


The space a stairway occupies can be great, but its form can be fitted into an interior in several ways. It can be treated as an additive form or as a volumetric solid from which space has been carved out for movement as well as rest.





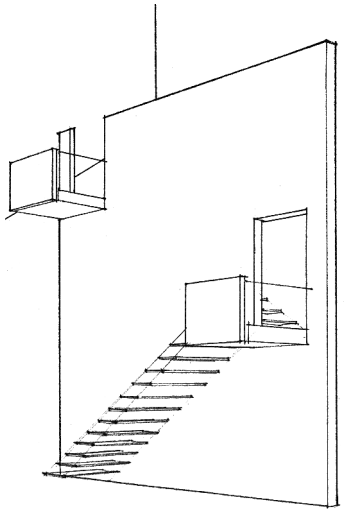
The stairway can run along one of the edges of a room, wrap around the space, or fill its volume. It can be woven into the boundaries of a space or be extended into a series of platforms for seating or terraces for activity.

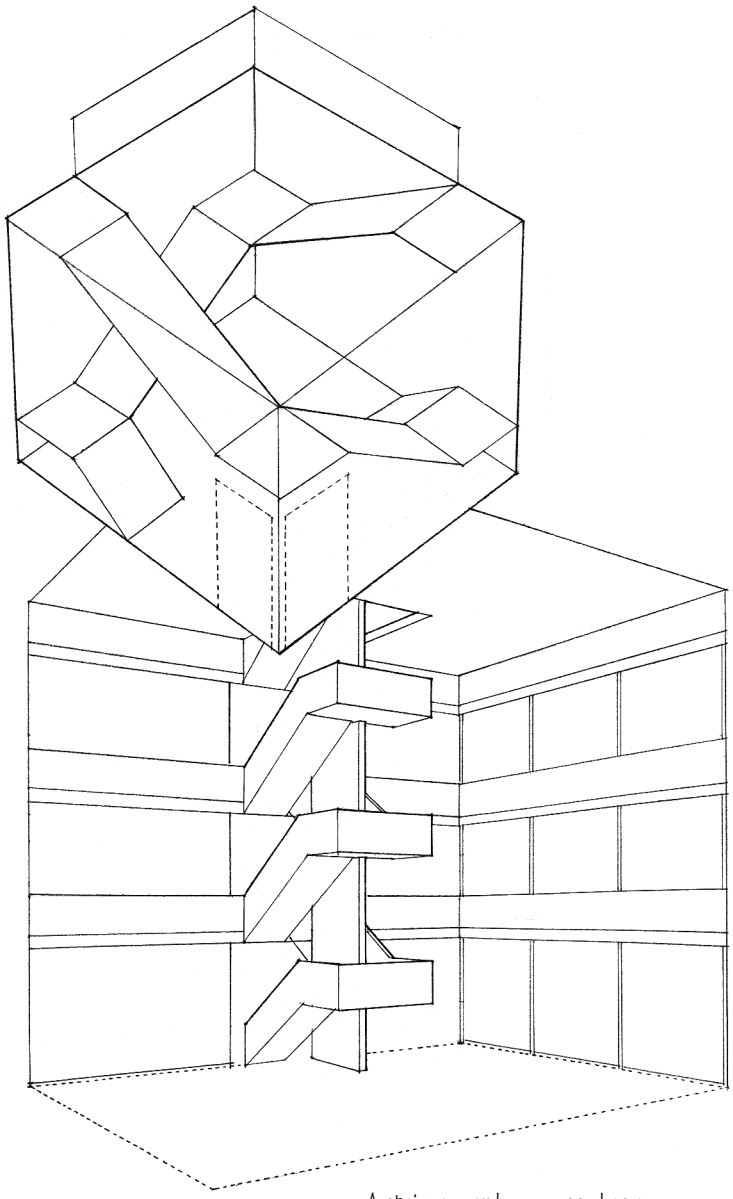


The path of a stair can rise between walls through a narrow shaft of space to offer access to a private place or signify unapproachability.

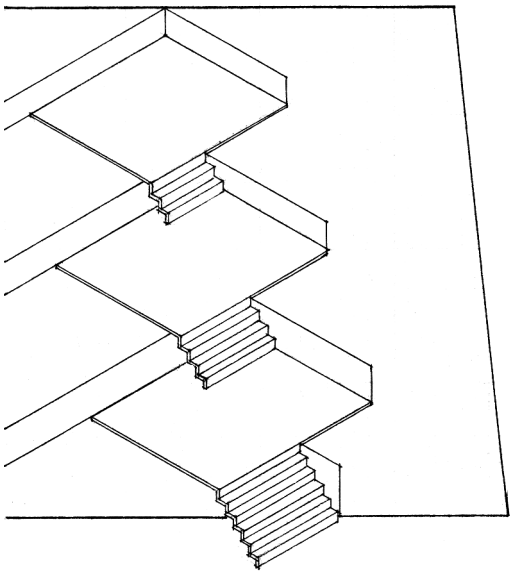
On the other hand, landings that are visible on approach invite ascent, as do treads that spill out at the bottom of a stairway.

A stairway can skirt an edge or wind around the boundaries of a space.





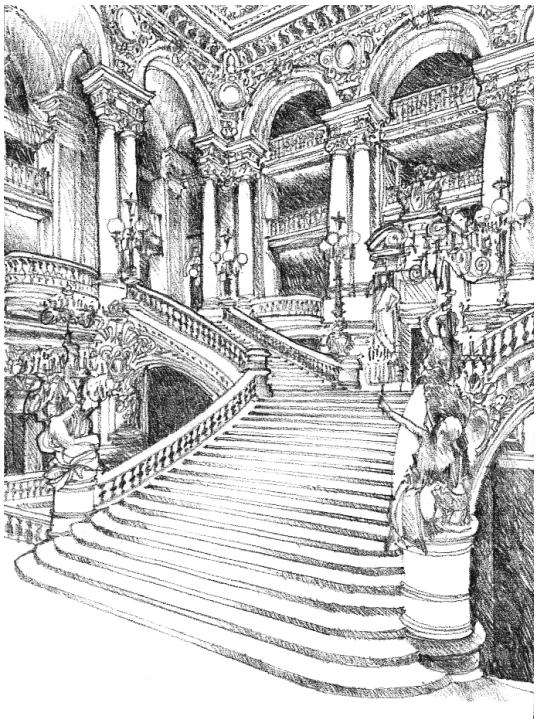
A stairway can be expressed as a sculptural form either attached to an edge or freestanding within a space.



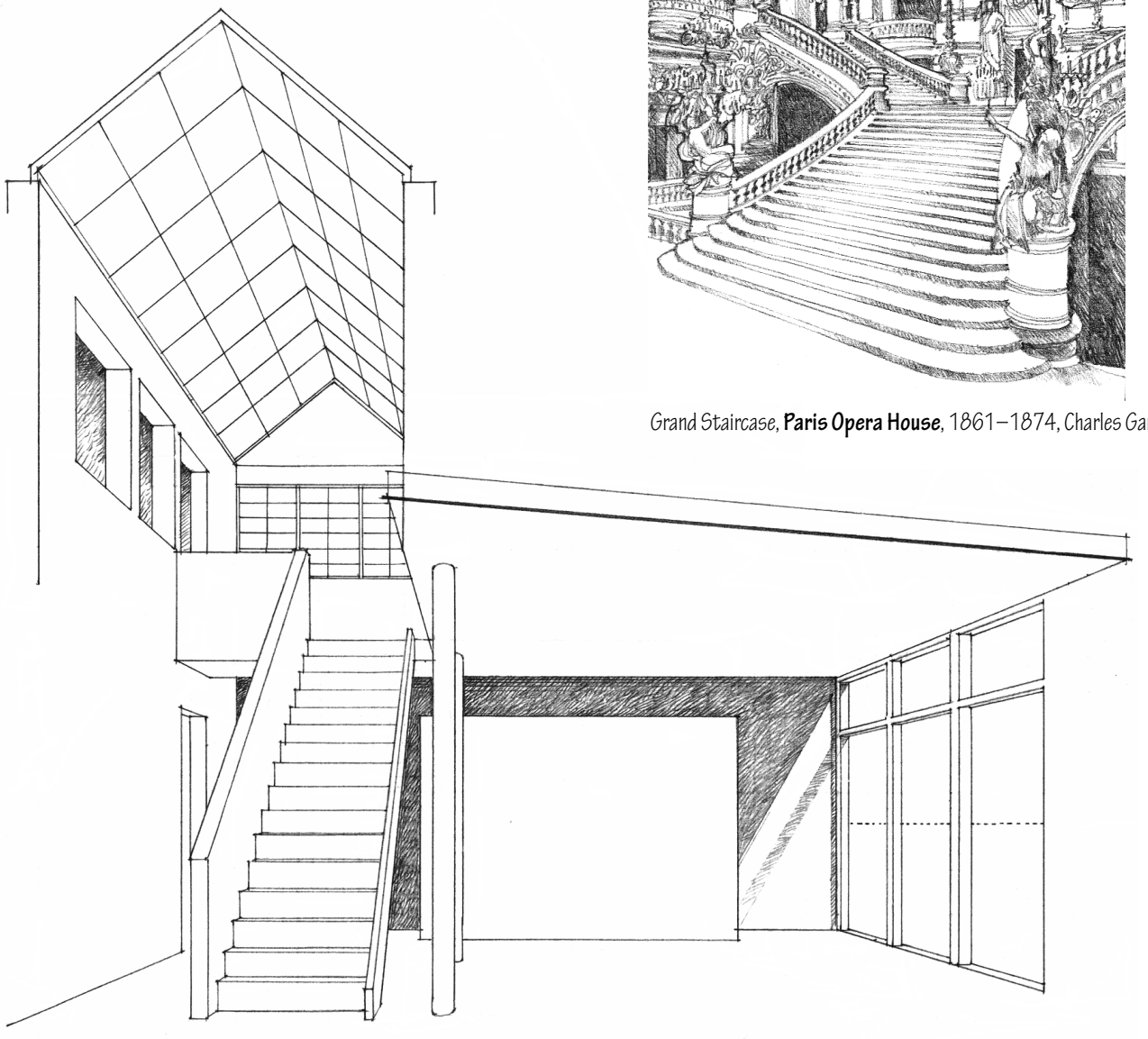
A stairway can be an organizing element and weave together a series of spaces at different levels of a building or with an outdoor space.

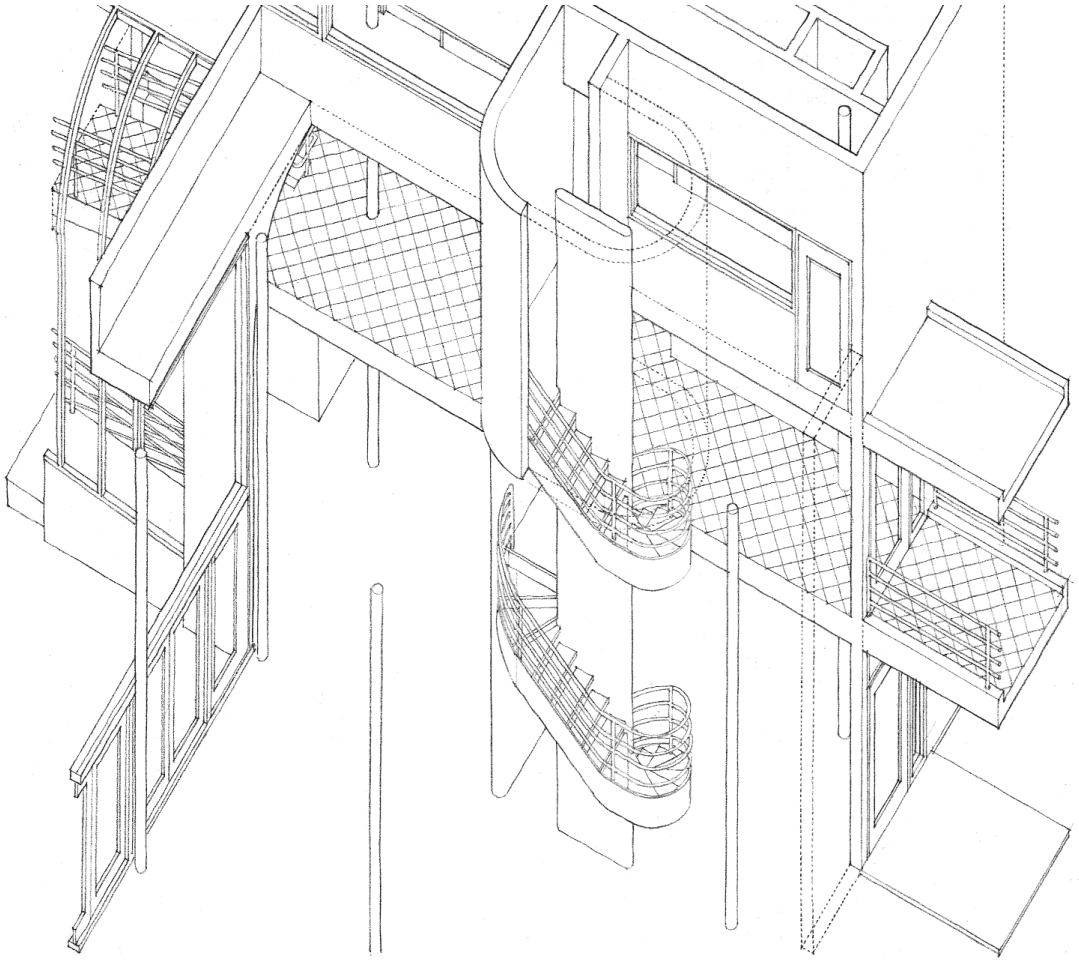
STAIRWAYS

Stairs are three-dimensional forms just as moving up or down a stairway is a three-dimensional experience. This three-dimensional quality can be exploited when we treat it as sculpture, freestanding within a space or attached to a wall plane. Further, a space can itself become an oversized elaborated stairway.

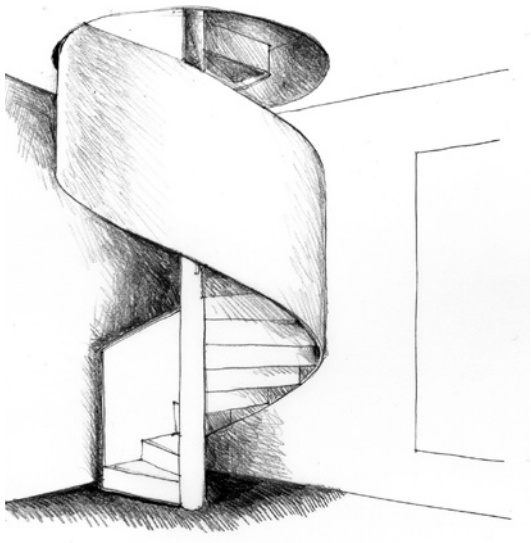


Grand Staircase, **Paris Opera House**, 1861–1874, Charles Garnier

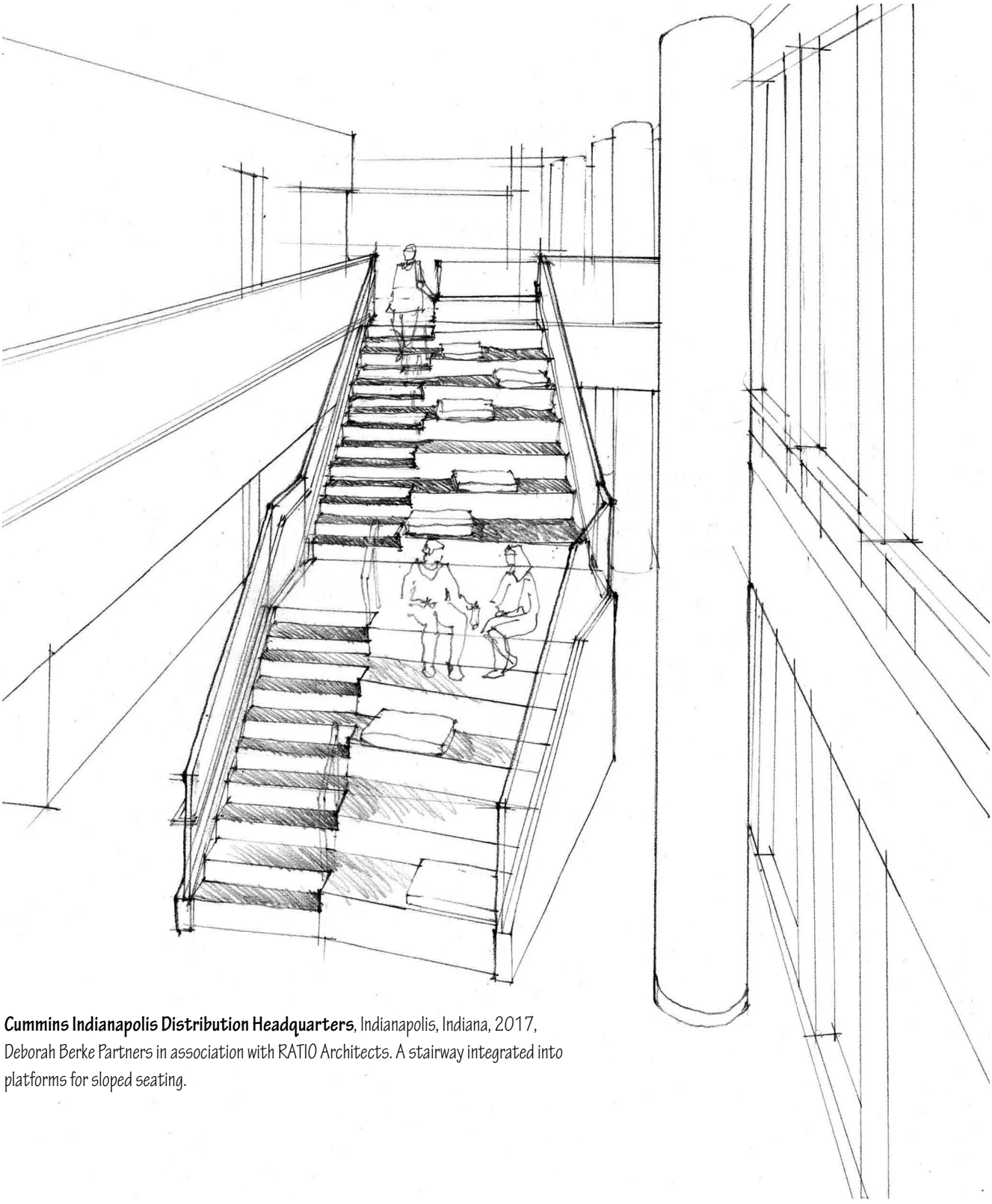




Plan oblique of living room stair, **House in Old Westbury**, New York, 1969–1971, Richard Meier



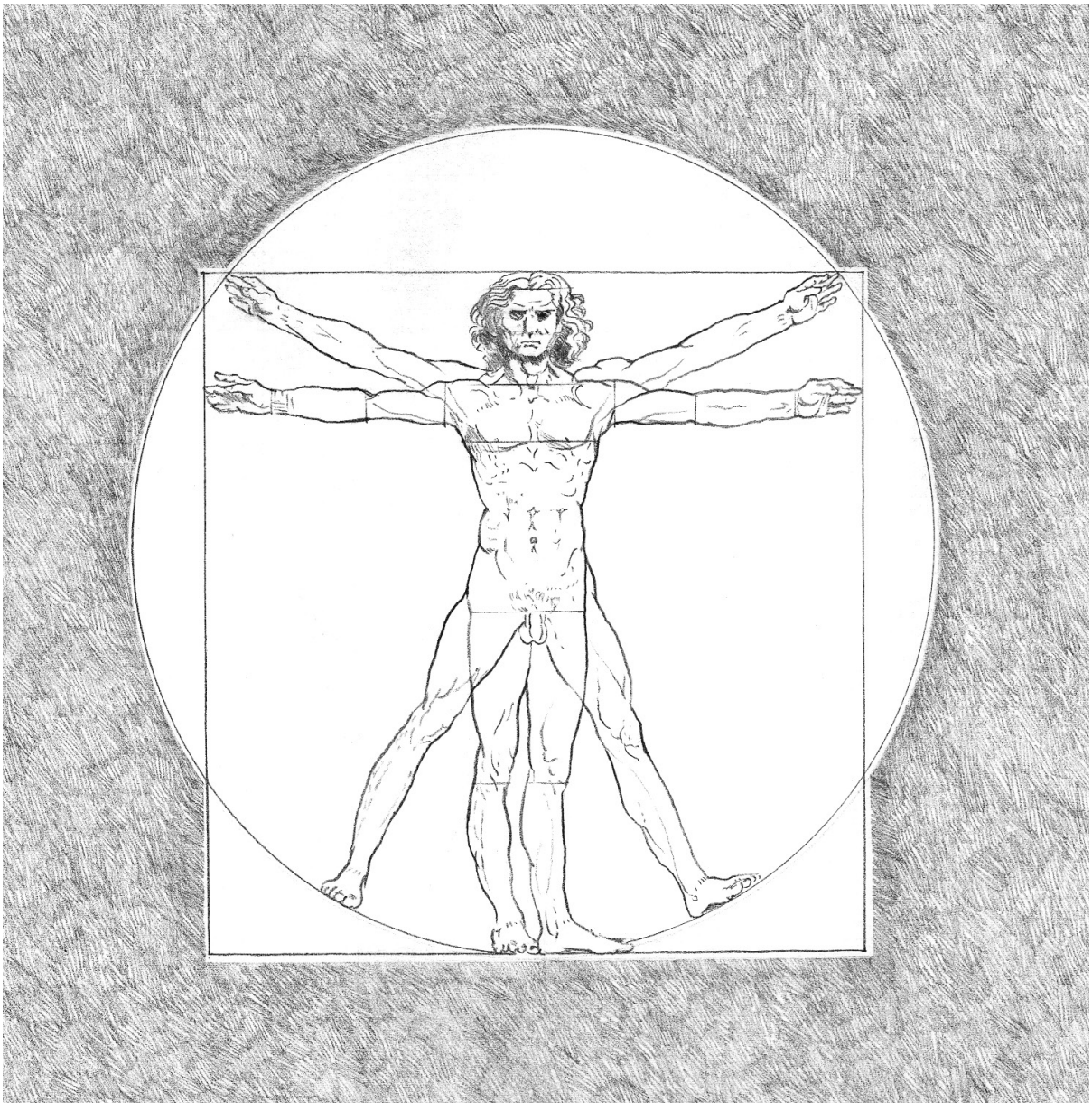
Stairway expressed as a freestanding sculptural form



Cummins Indianapolis Distribution Headquarters, Indianapolis, Indiana, 2017, Deborah Berke Partners in association with RATIO Architects. A stairway integrated into platforms for sloped seating.

A stairway woven into the colonnade surrounding a courtyard

Sannen-zaka, Kyoto. A historic, gently sloping pathway energized by shops, cafes, and inns,



Vitruvian man, Leonardo da Vinci

6

Proportion & Scale

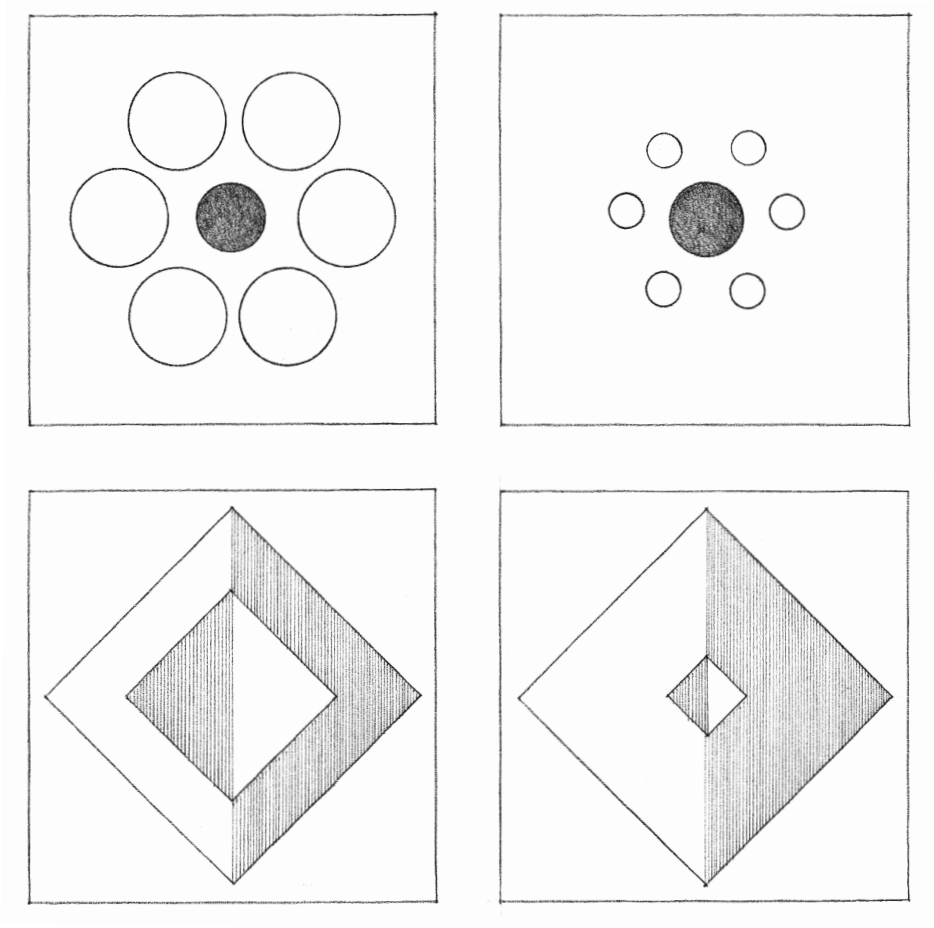
"... Within the Villa Foscari you are aware of the thickness of the walls that separate the rooms, each of which has been given definitive and precise form. At either end of the cross-arm of the central hall is a square room measuring 16 × 16 feet. It lies between a larger and a smaller rectangular room, the one 12 × 16, the other 16 × 24 feet, or twice as large. The smaller has its longer wall, the larger its shorter, in common with the square room. Palladio placed great emphasis on these simple ratios: 3:4, 4:4, and 4:6, which are those found in musical harmony. The width of the central hall is also based on 16. Its length is less exact because the thickness of the walls must be added to the simple dimensions of the rooms. The special effect of the hall in this firmly interlocked composition is produced by its great height, the barrel-vaulted ceiling towering high above the side rooms into the mezzanine. But, you may ask, does the visitor actually experience these proportions? The answer is yes—not the exact measurements but the fundamental idea behind them. You receive an impression of a noble, firmly integrated composition in which each room presents an ideal form within a greater whole. You also feel the rooms are related in size. Nothing is trivial—all is great and whole."

Steen Eiler Rasmussen
Experiencing Architecture
1962

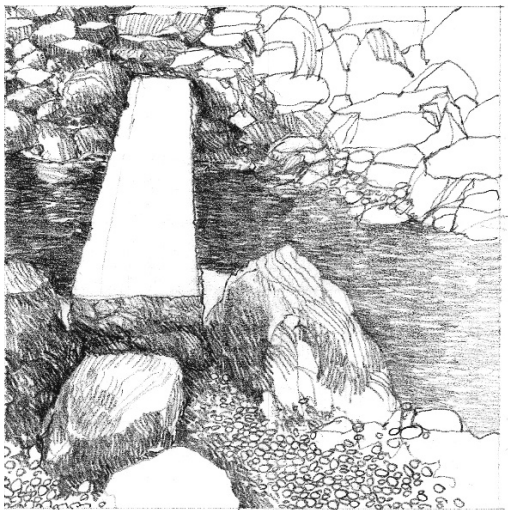
Architecture: Form, Space, & Order, Fifth Edition. Francis D. K. Ching.
© 2023 John Wiley & Sons, Inc. Published 2023 by John Wiley & Sons, Inc.
Companion Website: www.wiley.com/go/ching/architecturefso5e

PROPORTION & SCALE

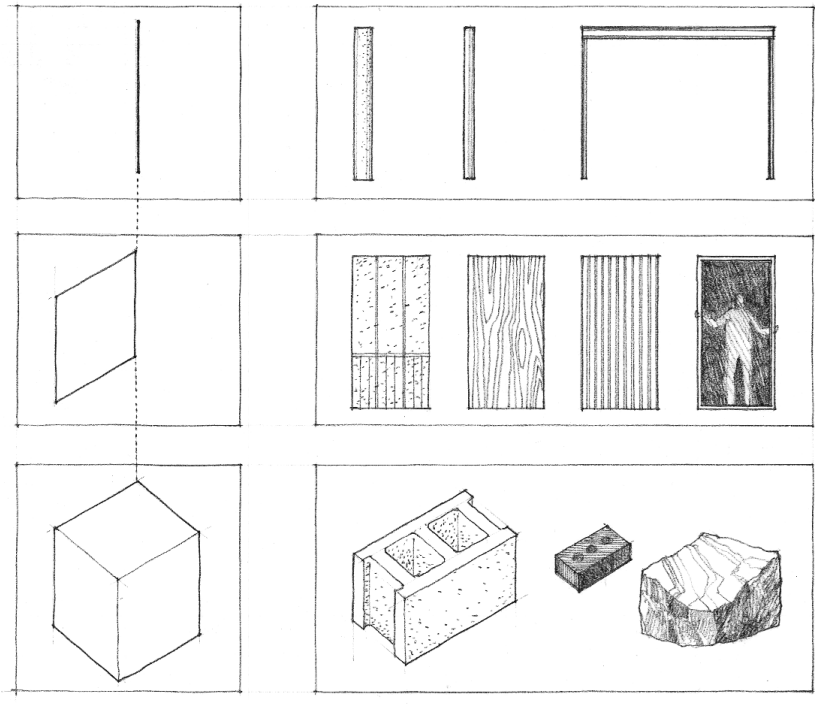
This chapter discusses the interrelated issues of proportion and scale. While scale alludes to the size of something compared to a reference standard or to the size of something else, proportion refers to the proper or harmonious relation of one part to another or to the whole. This relationship may not only be one of magnitude, but also of quantity or degree. While the designer usually has a range of choices when determining the proportions of things, some are given to us by the nature of materials, by how building elements respond to forces, and by how things are made.

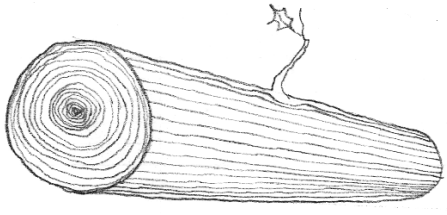


All building materials in architecture have distinct properties of elasticity, hardness, and durability. And they all have an ultimate strength beyond which they cannot extend themselves without fracturing, breaking, or collapsing. Since the stresses in a material resulting from the force of gravity increase with size, all materials also have rational dimensions beyond which they cannot go. For example, a stone slab that is 4 inches thick and 8 feet long can be reasonably expected to support itself as a bridge between two supports. But if its size were to increase fourfold, to 16 inches thick and 32 feet long, it would probably collapse under its own weight. Even a strong material like steel has lengths beyond which it cannot span without exceeding its ultimate strength.

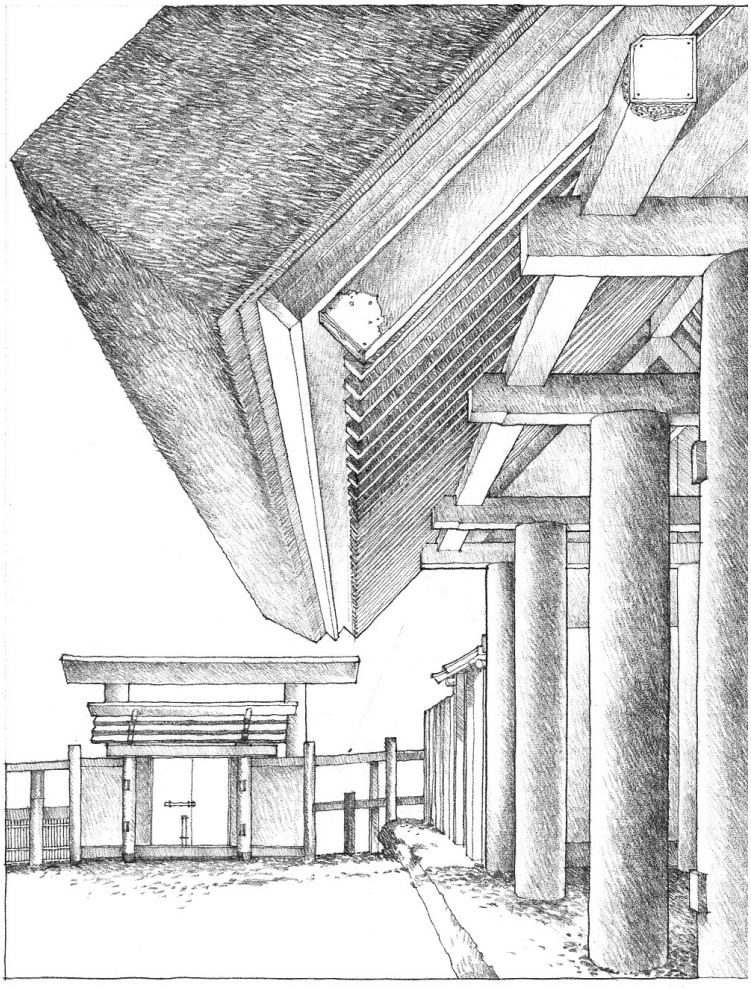


All materials also have rational proportions that are dictated by their inherent strengths and weaknesses. Masonry units like brick, for example, are strong in compression and depend on their mass for strength. Such materials are therefore volumetric in form. Materials like steel are strong in both compression and tension and can therefore be formed into linear columns and beams as well as planar sheet materials. Wood, being a flexible and fairly elastic material, can be used as linear posts and beams, planar boards, and as a volumetric element in log cabin construction.





STRUCTURAL PROPORTIONS

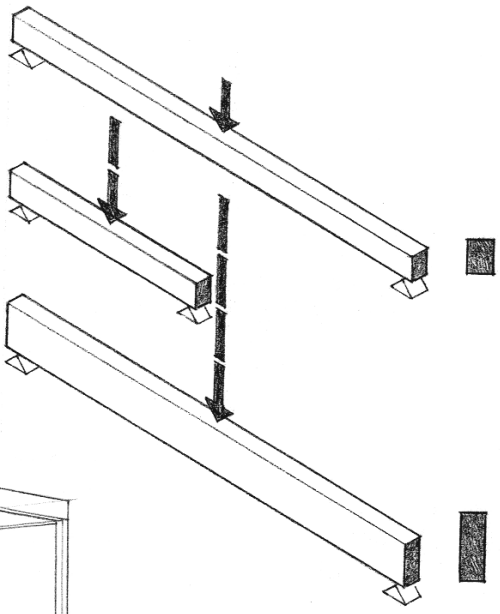


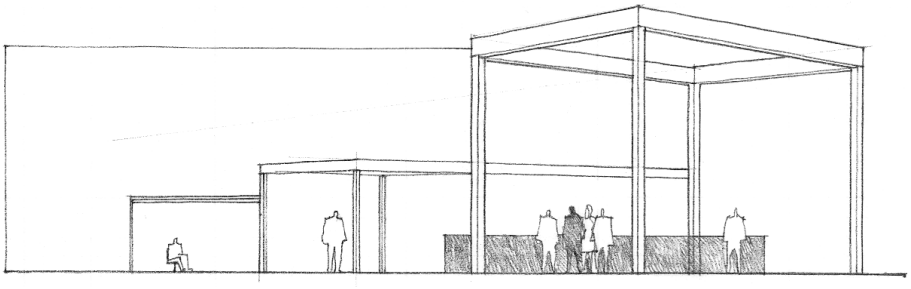
South gateway of the third fence of **Naigu**, **Ise Inner Shrine**, Mie Prefecture, Japan, A.D. 690

In the construction of architecture, structural elements are called upon to span spaces and transmit their loads through vertical supports to the foundation system of a building. The size and proportion of these elements are directly related to the structural tasks they perform and can therefore be visual indicators of the size and scale of the spaces they help enclose.

Beams, for example, transmit their loads horizontally across space to their vertical supports. If the span or load of a beam were doubled, its bending stresses would likewise double, possibly causing it to collapse. But if its depth were doubled, its strength would increase fourfold. Depth, therefore, is the critical dimension of a beam and its depth-to-span ratio can be a useful indicator of its structural role.

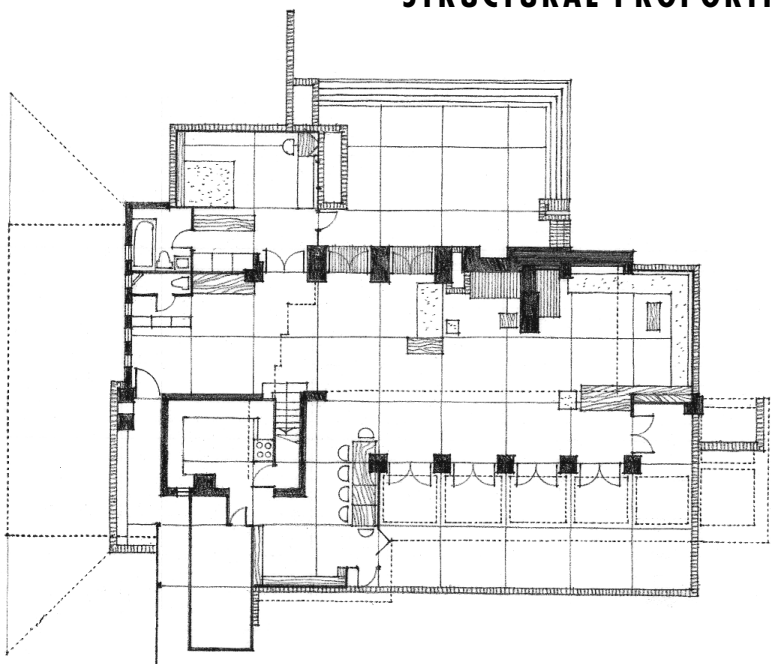
In a similar manner, columns become thicker as their loads and unsupported height increase. Together, beams and columns form a skeletal structural framework that defines modules of space. By their size and proportion, columns and beams articulate space and give it scale and a hierarchical structure. This can be seen in the way joists are supported by beams, which in turn are supported by girders. Each element increases in depth as its load and span increase in size.



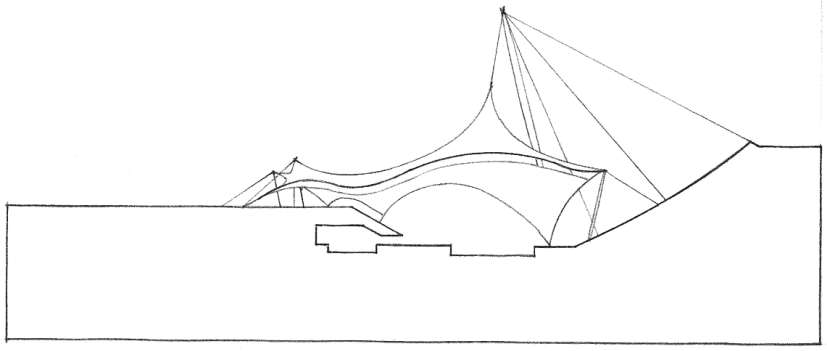


The proportions of other structural elements, such as bearing walls, floor and roof slabs, vaults, and domes, also give us visual clues to their role in a structural system as well as the nature of their material. A masonry wall, being strong in compression but relatively weak in bending, will be thicker than a reinforced concrete wall doing the same work. A steel column will be thinner than a wood post supporting the same load. A 4-inch-thick reinforced concrete slab will span farther than 4-inch wood decking.

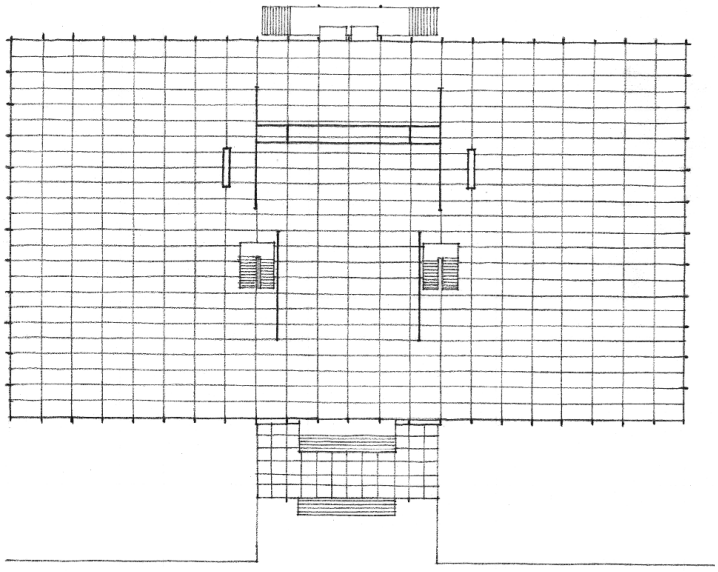
As a structure depends less on the weight and stiffness of a material and more on its geometry for stability, as in the case of a membrane structure or a space frame, its elements will get thinner and thinner until they lose their ability to give a space scale and dimension.



Wood and Brick
Schwartz House, Two Rivers, Wisconsin, 1939, Frank Lloyd Wright

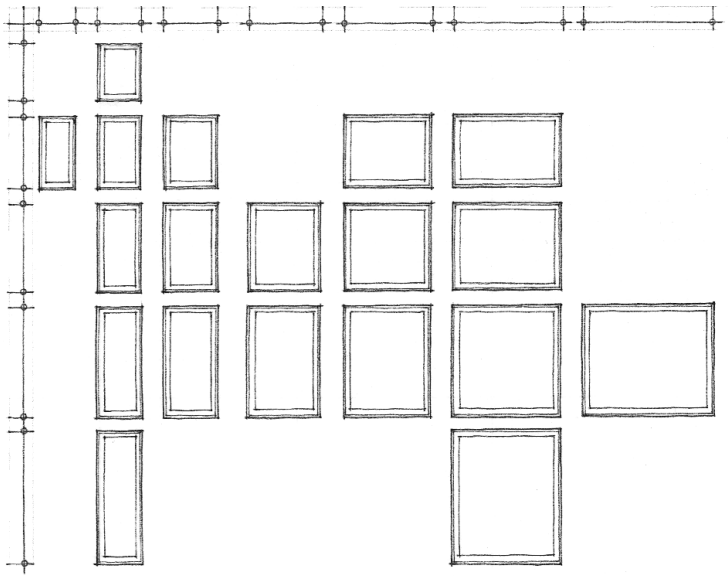


Membrane
Roof of **Olympic Swimming Arena**, Munich, Germany, 1972, Fred Otto



Steel
Crown Hall, Illinois Institute of Technology, Chicago, 1956, Mies van der Rohe

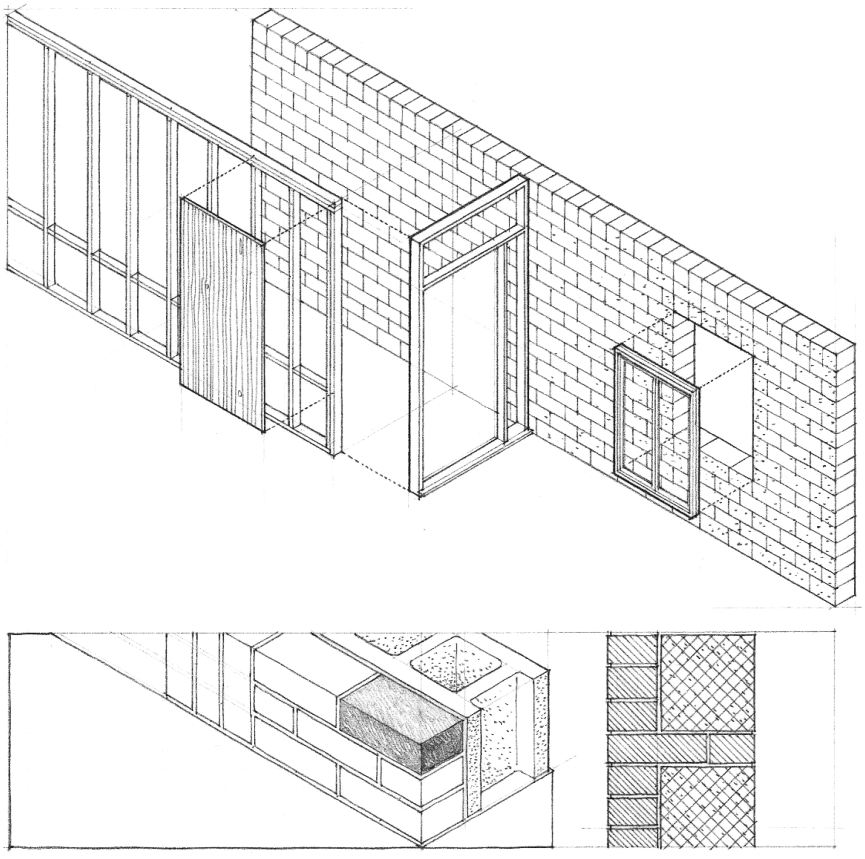
MANUFACTURED PROPORTIONS



Standard Casement Window Units

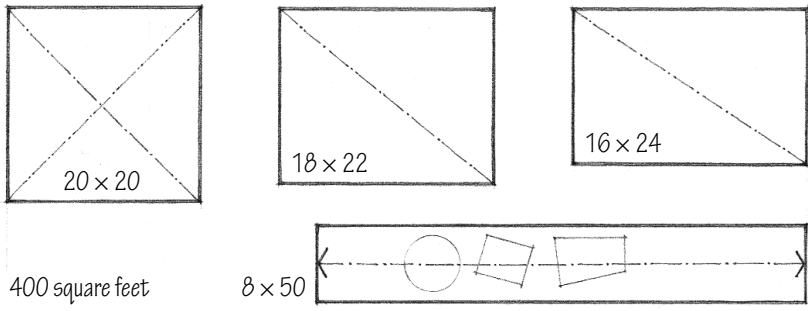
Many architectural elements are sized and proportioned not only according to their structural properties and function but also by the process through which they are manufactured. Because these elements are mass-produced in factories, they have standard sizes and proportions imposed on them by the individual manufacturers or by industry standards.

Concrete block and common brick, for example, are produced as modular building units. Although they differ from each other in size, both are proportioned on a similar basis. Plywood and other sheathing materials also are manufactured as modular units with fixed proportions. Steel sections have fixed proportions generally agreed upon by the steel manufacturers and the American Institute of Steel Construction. Windows and doors have proportions that are set by the individual manufacturers of the units.



Since these and other materials must ultimately come together and achieve a high degree of fit in the construction of a building, the standard sizes and proportions of factory-produced elements affect the size, proportion, and spacing of other materials as well. Standard door and window units are sized and proportioned to fit into modular masonry openings. Wood or metal studs and joists are spaced to accept modular sheathing materials.

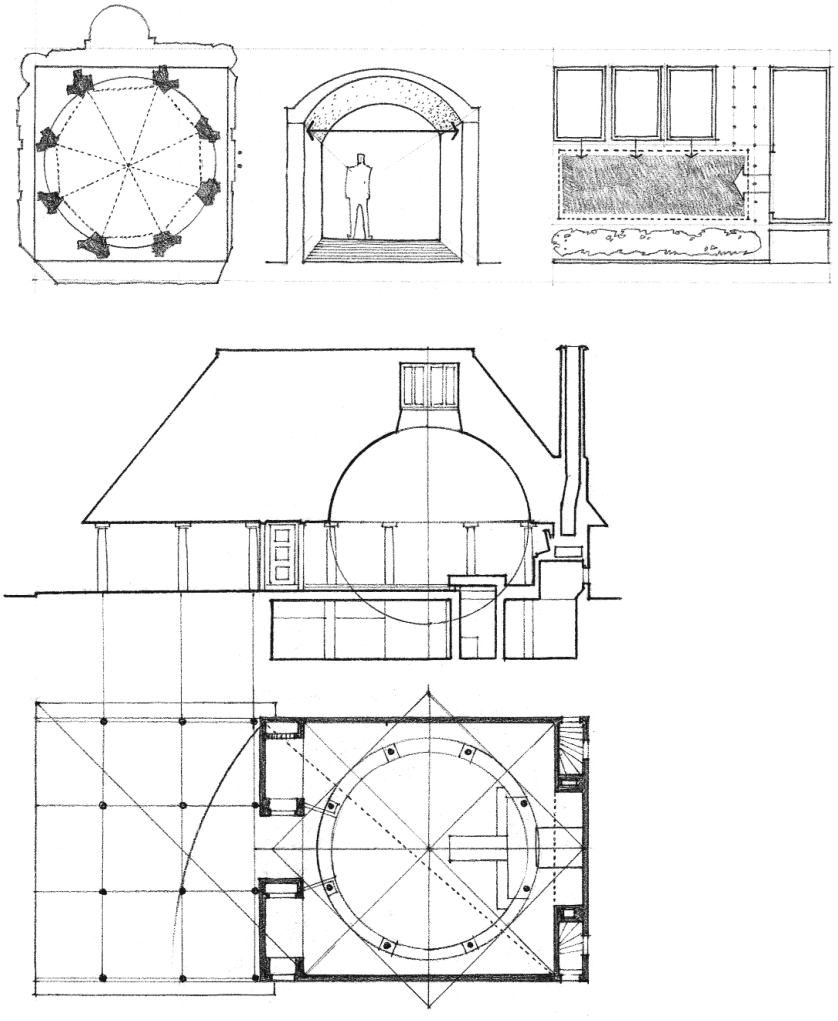
Even considering the proportional constraints imposed on a form by the nature of its material, its structural function, or by the manufacturing process, the designer still has the ability to control the proportion of the forms and spaces within and around a building. The decision to make a room square or oblong in plan, intimate or lofty in scale, or to endow a building with an imposing, higher-than-usual facade, legitimately falls to the designer. But on what basis are these decisions made?



If a space 400 square feet in area were required, what dimensions—what ratios of width-to-length and length-to-height—should it have? Of course, the functioning of the space and the nature of the activities to be accommodated will influence its form and proportion.

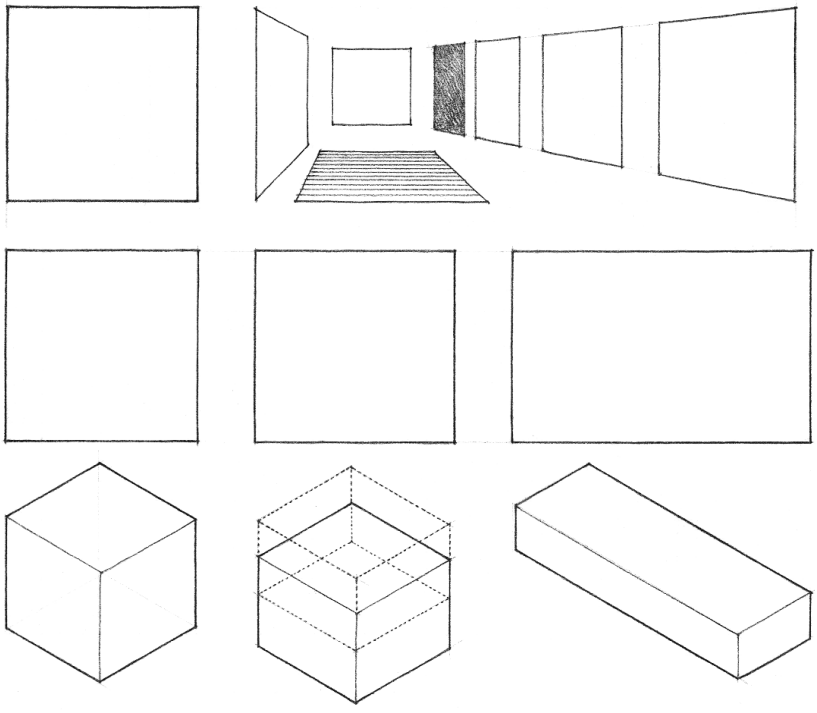
A square space, having four equal faces, is static in nature. If its length expands and dominates its width, it becomes more dynamic. While square and oblong spaces define places for activity, linear spaces encourage movement and are susceptible to subdivision into a number of zones.

A technical factor, such as its structure, might limit one or more of its dimensions. Its context—the exterior environment or an adjacent interior space—might pressure its form. The decision might be to recall a space from another time and place and to simulate its proportions. Or the decision might be based finally on an aesthetic, visual judgment of the "desirable" relationships among the dimensions of the parts and the whole of a building.



Woodland Chapel,
Stockholm, Sweden, 1918–1920, Erik Gunnar Asplund

PROPORTIONING SYSTEMS



In truth, our perception of the physical dimensions of architecture, of proportion and scale, is imprecise. It is distorted by the foreshortening of perspective and distance, and by cultural biases, and is thus difficult to control and predict in an objective and precise manner.

Small or slight differences in the dimensions of a form are especially difficult to discern. While a square, by definition, has four equal sides and four right angles, a rectangle can appear to be exactly square, almost a square, or very much unlike a square. It can appear to be long, short, stubby, or squat, depending on our point of view. We use these terms to give a form or figure a visual quality that is largely a result of how we perceive its proportions. It is not, however, an exact science.

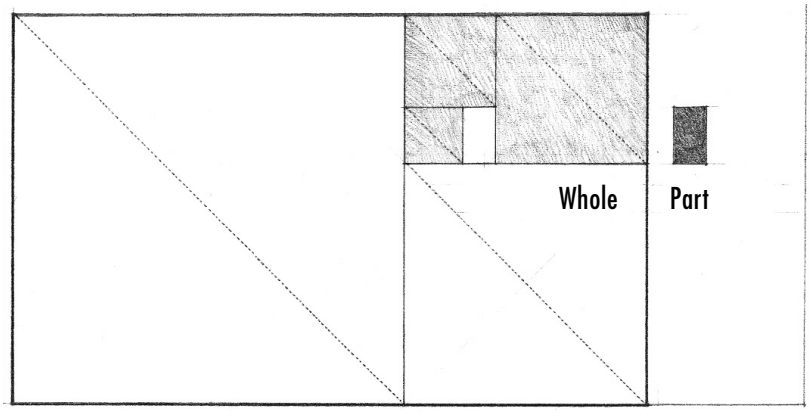
If the precise dimensions and relationships of a design that is regulated by a proportioning system cannot be objectively perceived in a similar manner by everyone, why are proportioning systems useful and of particular significance in architectural design?

The intent of all theories of proportions is to create a sense of order and harmony among the elements in a visual construction. According to Euclid, a ratio refers to the quantitative comparison of two similar things, while proportion refers to the equality of ratios. Underlying any proportioning system, therefore, is a characteristic ratio, a permanent quality that is transmitted from one ratio to another. Thus, a proportioning system establishes a consistent set of visual relationships between the parts of a building, as well as between the parts and the whole. Although these relationships may not be immediately perceived by the casual observer, the visual order they create can be sensed, accepted, or even recognized through a series of repetitive experiences. Over a period of time, we might begin to see the whole in the part, and the part in the whole.

Ratio: $\frac{a}{b}$

Proportion: $\frac{a}{b} = \frac{c}{d}$ or $\frac{a}{b} = \frac{b}{c} = \frac{c}{d} = \frac{d}{e}$

Proportion is the equality between two ratios in which the first of the four terms divided by the second equals the third divided by the fourth.



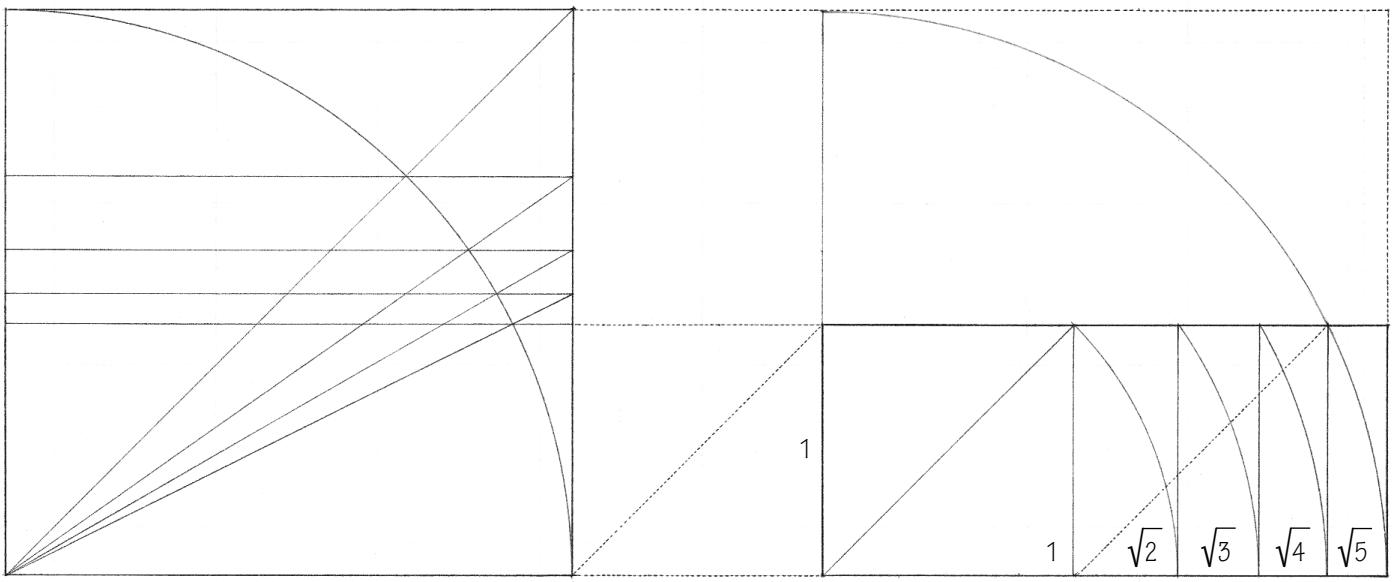
PROPORTIONING SYSTEMS

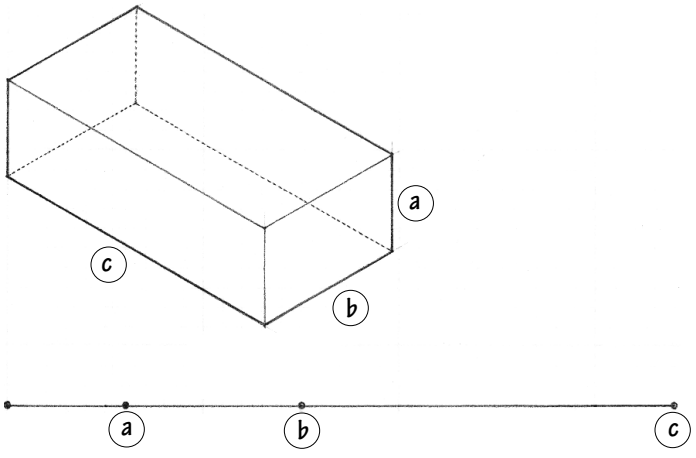
Proportioning systems go beyond the functional and technical determinants of architectural form and space to provide an aesthetic rationale for their dimensions. They can visually unify the multiplicity of elements in an architectural design by having all of its parts belong to the same family of proportions. They can provide a sense of order in, and heighten the continuity of, a sequence of spaces. They can establish relationships between the exterior and interior elements of a building.

A number of theories of "desirable" proportions have been developed in the course of history. The notion of devising a system for design and communicating its means is common to all periods. Although the actual system varies from time to time, the principles involved and their value to the designer remain the same.

Theories of Proportion:

- Golden Section
- Classical Orders
- Renaissance Theories
- Modulor
- Ken
- Anthropometry
- Scale — A fixed proportion used in determining measurements and dimensions





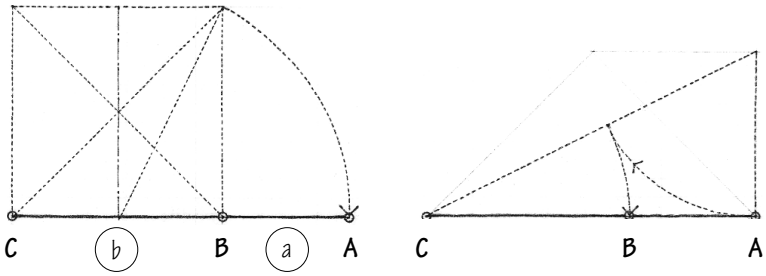
Types of Proportion:

Arithmetic $\frac{c-b}{b-a} = \frac{c}{c}$ (*e.g.*, 1, 2, 3)

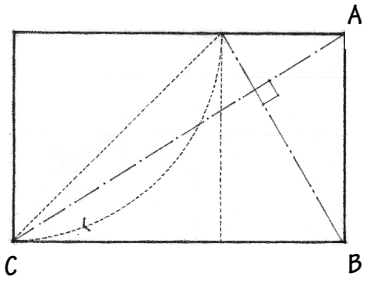
Geometric $\frac{c-b}{b-a} = \frac{c}{b}$ (*e.g.*, 1, 2, 4)

Harmonic $\frac{c-b}{b-a} = \frac{c}{a}$ (*e.g.*, 2, 3, 6)

GOLDEN SECTION



The geometric construction of the Golden Section, first by extension, and then by division.

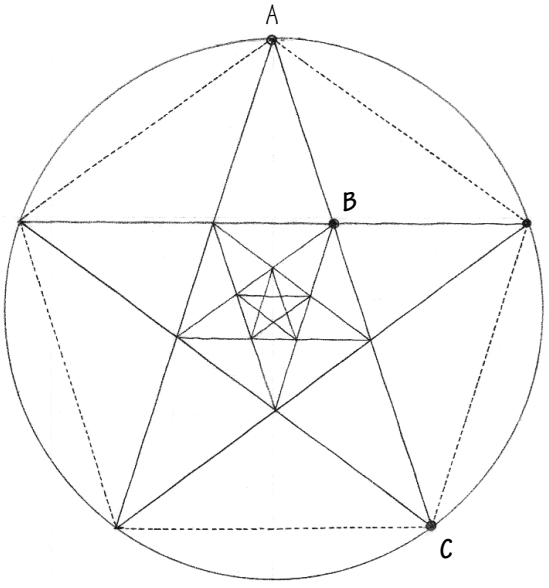


$AB = a$

$BC = b$

$Ø$ = Golden Section

$$Ø = \frac{a}{b} = \frac{b}{a+b} = 0.618$$



Mathematical systems of proportion originate from the Pythagorean concept of "all is number" and the belief that certain numerical relationships manifest the harmonic structure of the universe. One of these relationships that has been in use ever since the days of antiquity is the proportion known as the Golden Section. The Greeks recognized the dominating role the Golden Section played in the proportions of the human body. Believing that both humanity and the shrines housing their deities should belong to a higher universal order, they utilized these same proportions in their temple structures. Renaissance architects also explored the Golden Section in their work. In more recent times, Le Corbusier based his Modulor system on the Golden Section. Its use in architecture endures even today.

The Golden Section can be defined as the ratio between two sections of a line, or the two dimensions of a plane figure, in which the lesser of the two is to the greater as the greater is to the sum of both. It can be expressed algebraically by the equation of two ratios:

$$\frac{a}{b} = \frac{b}{a+b}$$

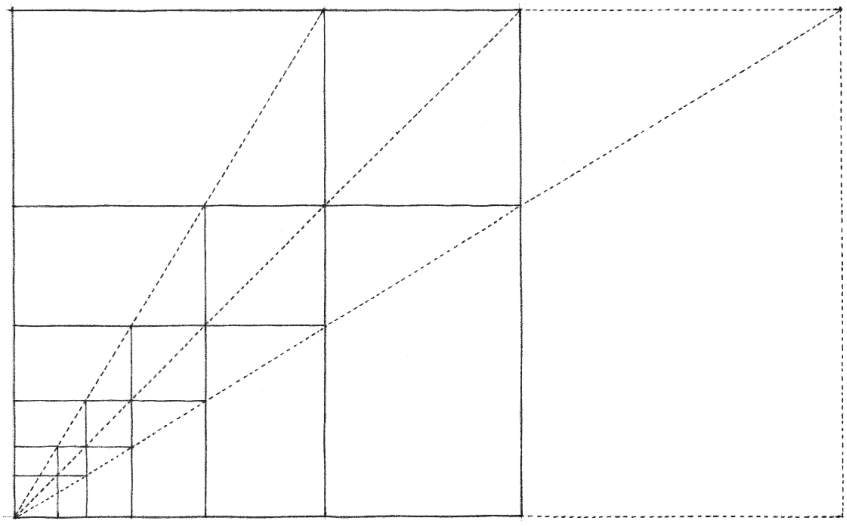
The Golden Section has some remarkable algebraic and geometric properties that account for its existence in architecture as well as in the structures of many living organisms. Any progression based on the Golden Section is at once additive and geometrical.

Another progression that closely approximates the Golden Section in whole numbers is the Fibonacci Series: 1, 1, 2, 3, 5, 8, 13. . . . Each term again is the sum of the two preceding ones, and the ratio between two consecutive terms tends to approximate the Golden Section as the series progresses to infinity.

In the numerical progression: $1, Ø^1, Ø^2, Ø^3 \ldots Ø^n$, each term is the sum of the two preceding ones.

GOLDEN SECTION

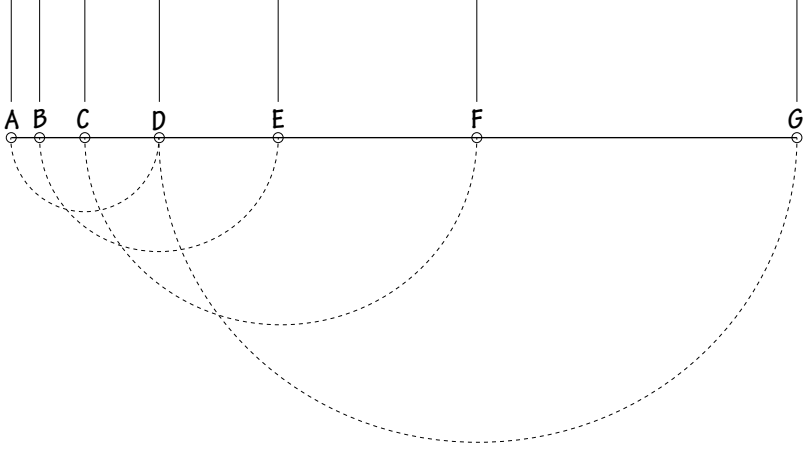
A rectangle whose sides are proportioned according to the Golden Section is known as a Golden Rectangle. If a square is constructed on its smaller side, the remaining portion of the original rectangle would be a smaller but similar Golden Rectangle. This operation can be repeated indefinitely to create a gradation of squares and Golden Rectangles. During this transformation, each part remains similar to all of the other parts, as well as to the whole. The diagrams on this page illustrate this additive and geometrical growth pattern of progressions based on the Golden Section.

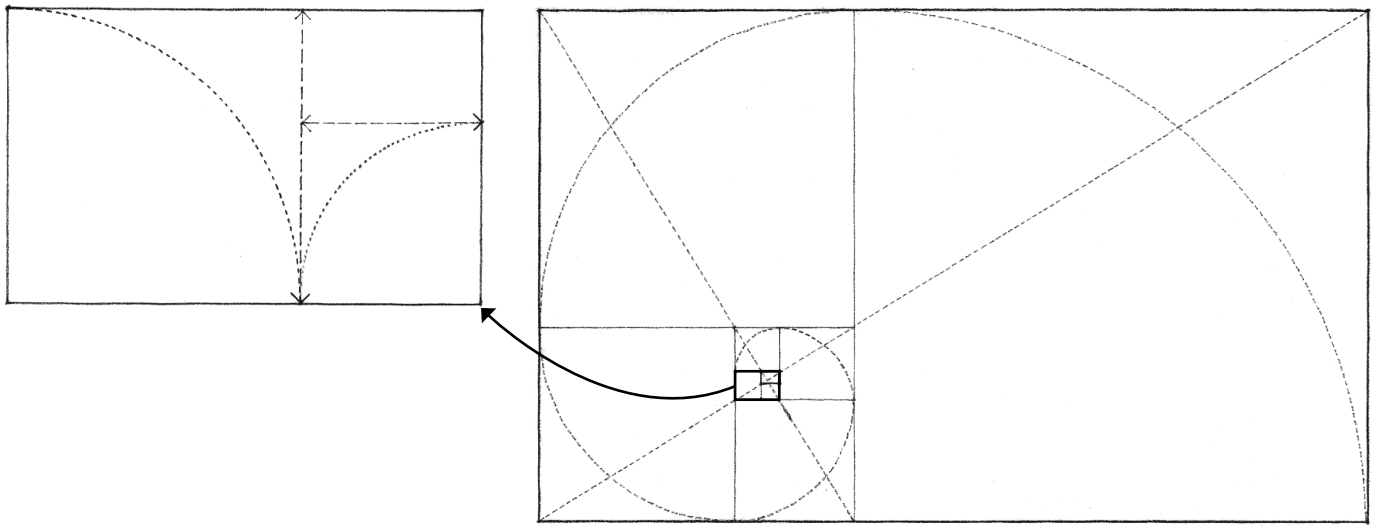


$$\frac{AB}{BC} = \frac{BC}{CD} = \frac{CD}{DE} \ldots\ldots = \emptyset$$

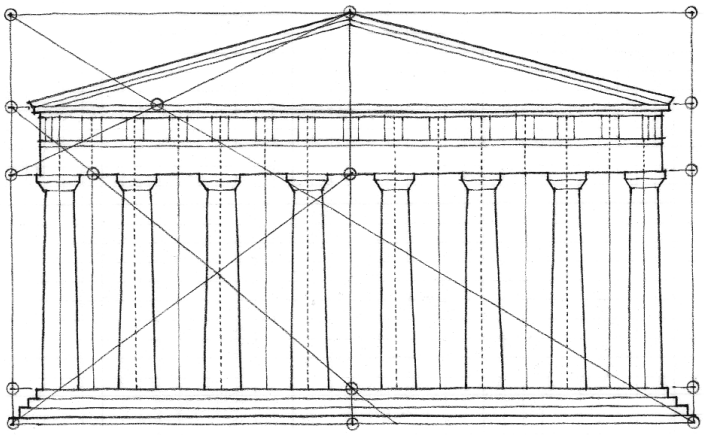
$$AB + BC = CD$$
$$BC + CD = DE$$
$$\vdots$$

etc.

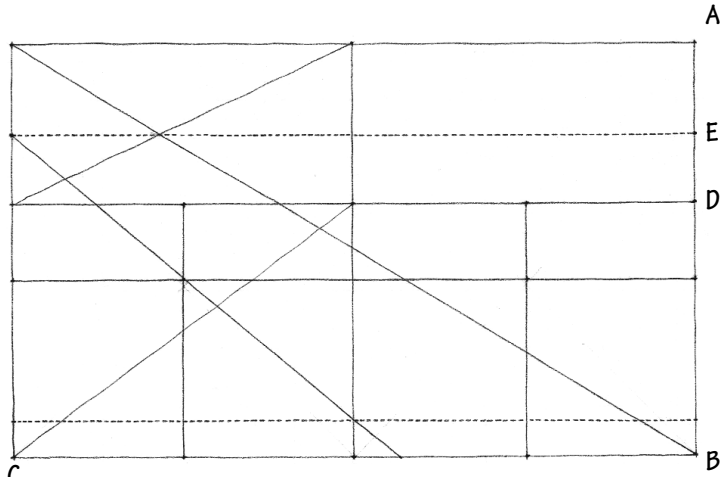




GOLDEN SECTION

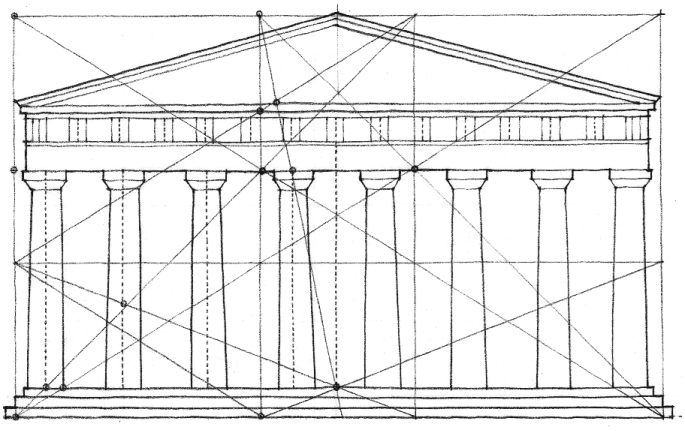


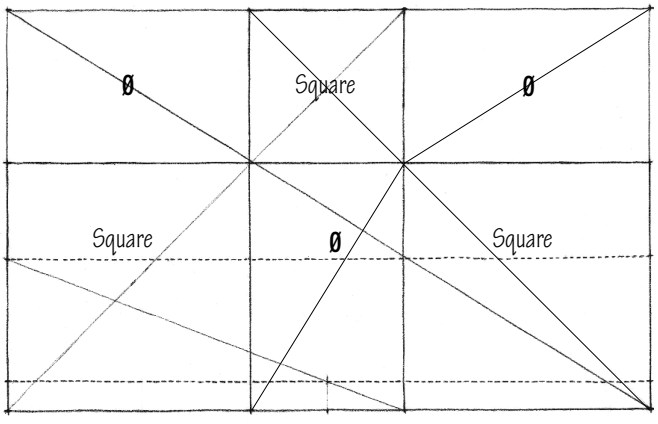
The Parthenon, Athens, 447–432 B.C., Ictinus and Callicrates

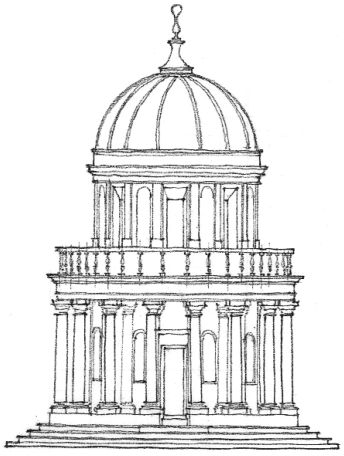


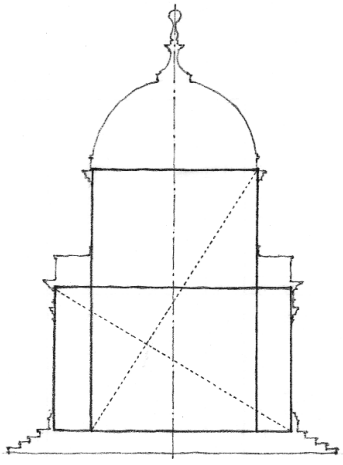
$$\frac{AB}{BC} = \frac{BD}{AB} = \frac{AD}{BD} = \frac{AE}{AD}$$

These two graphic analyses illustrate the use of the Golden Section in the proportioning of the facade of the Parthenon. It is interesting to note that while both analyses begin by fitting the facade into a Golden Rectangle, each analysis then varies from the other in its approach to proving the existence of the Golden Section and its effect on the dimensions and distribution of elements across the facade.

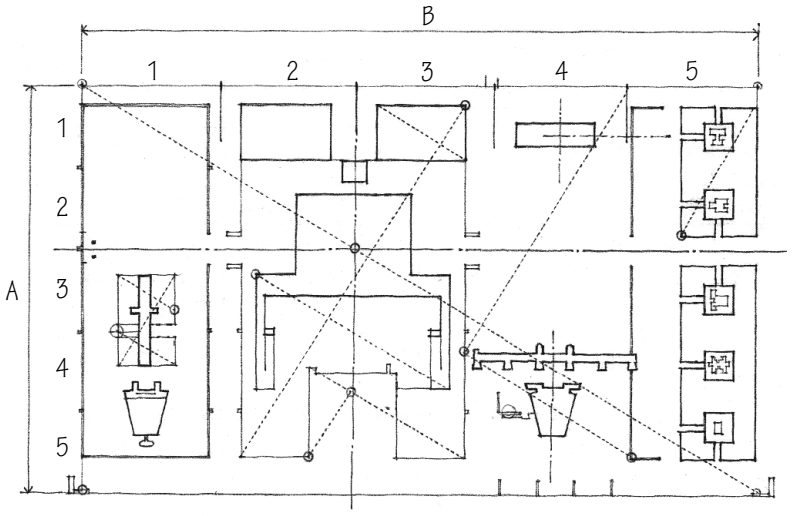


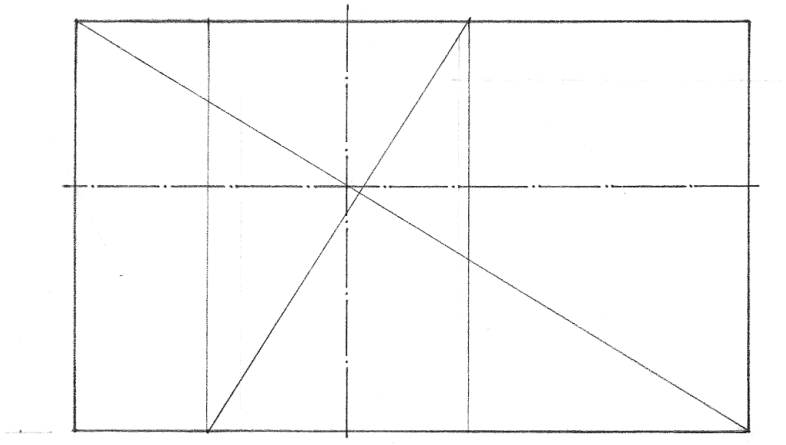




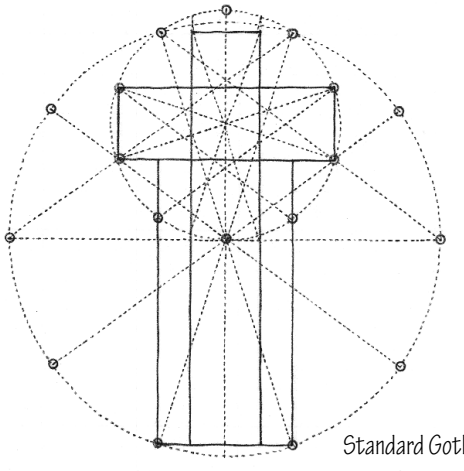


Tempietto, St. Pietro in Montorio, Rome, 1502–1510, Donato Bramante



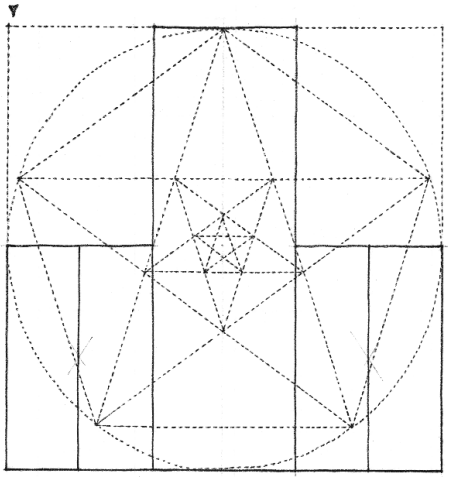


World Museum (Project), Geneva, 1929, Le Corbusier



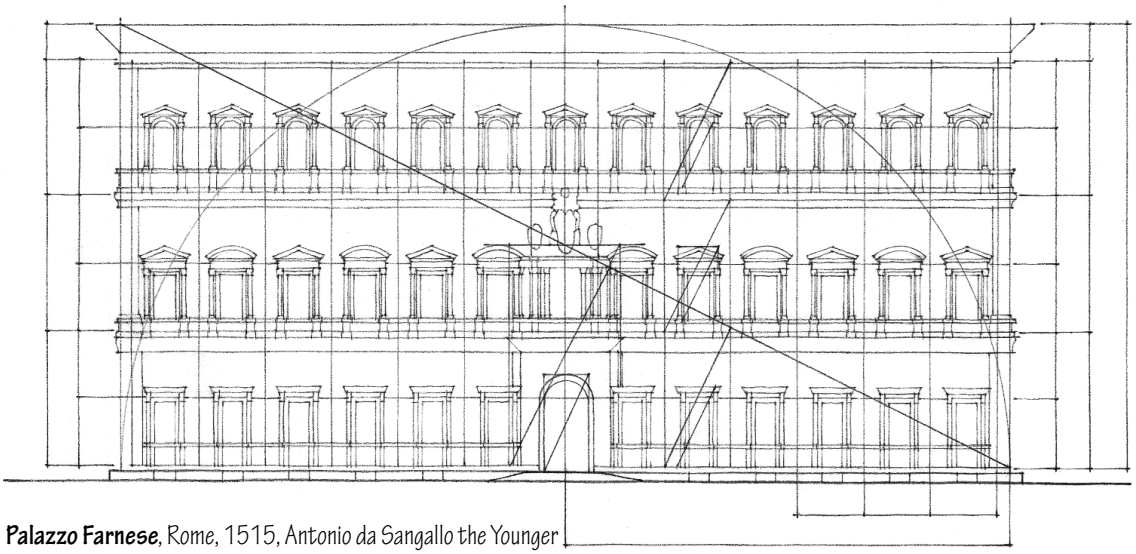
Standard Gothic Plan and Section

After Moessel

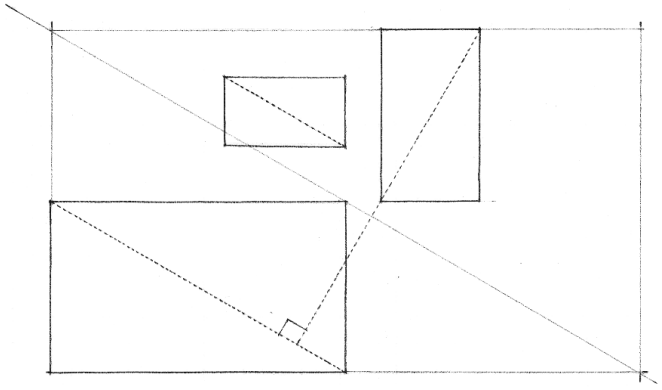


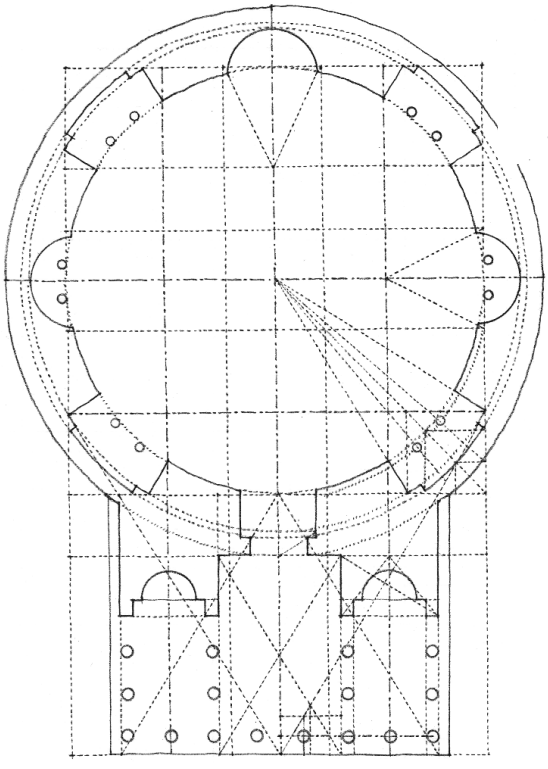
After F.M. Lund

REGULATING LINES



Palazzo Farnese, Rome, 1515, Antonio *da* Sangallo the Younger

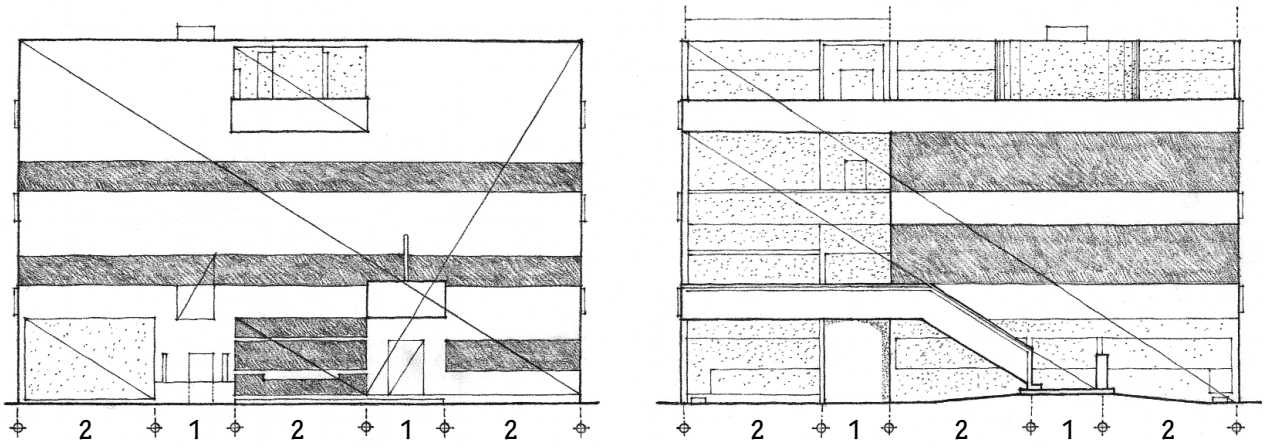




The Pantheon, Rome, A.D. 120–124

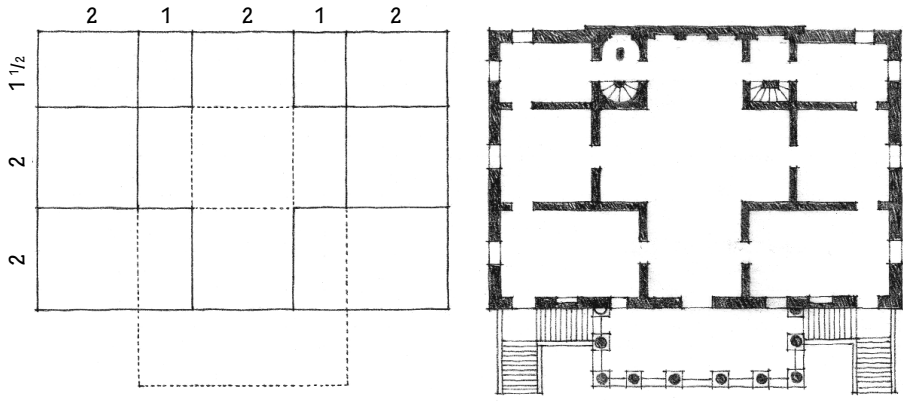
If the diagonals of two rectangles are either parallel or perpendicular to each other, they indicate that the two rectangles have similar proportions. These diagonals, as well as lines that indicate the common alignment of elements, are called regulating lines. They were seen previously in the discussion of the Golden Section, but they can also be used to control the proportion and placement of elements in other proportioning systems as well. Le Corbusier, in *Towards a New Architecture*, stated the following:

"A regulating line is an assurance against capriciousness; it is a means of verification which can ratify all work created in fervour. . . . It confers on the work the quality of rhythm. The regulating line brings in this tangible form of mathematics which gives the reassuring perception of order. The choice of a regulating line fixes the fundamental geometry of the work. . . . It is a means to an end; it is not a recipe."



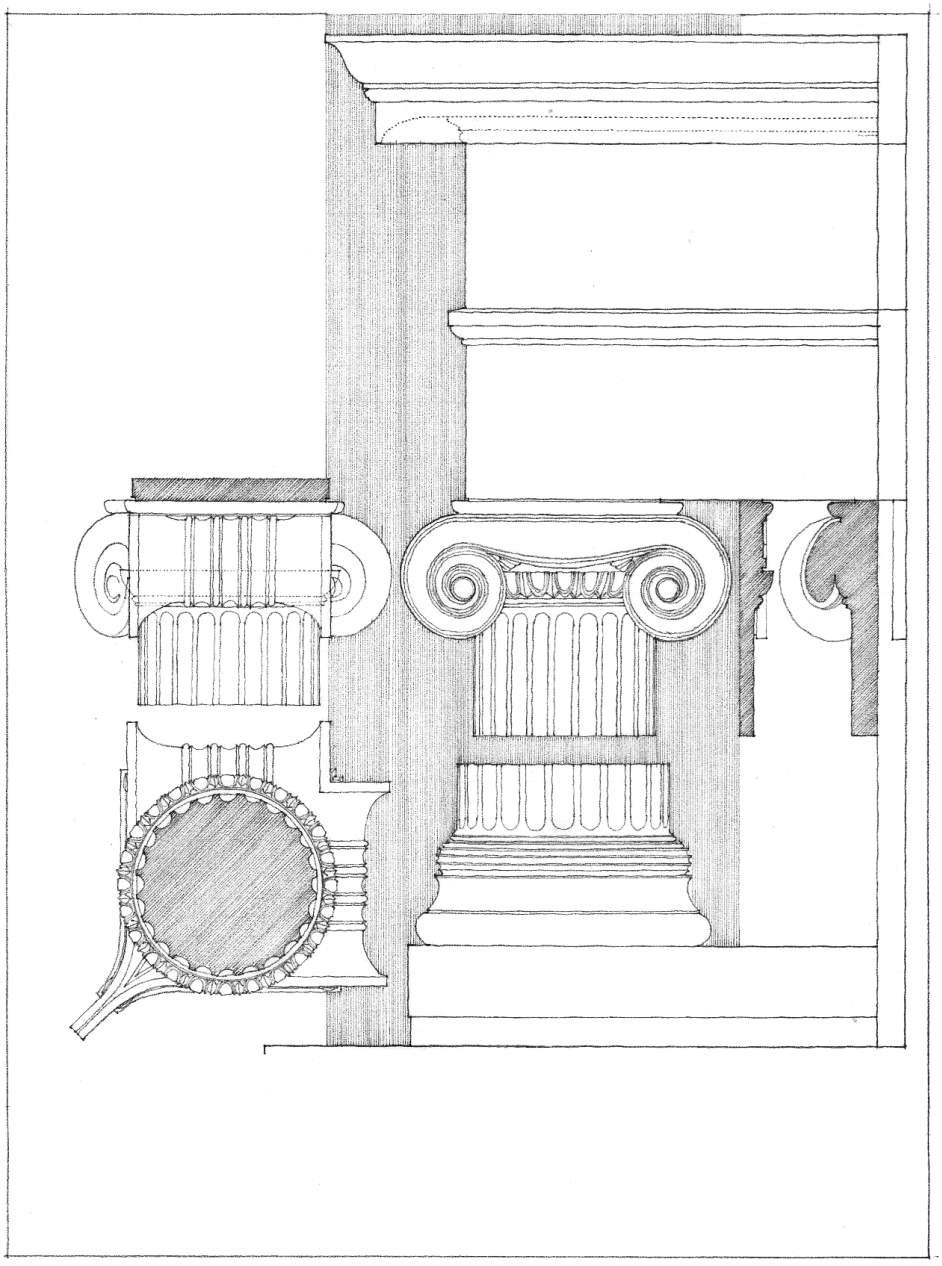
Villa Garches, Vaucresson, France, 1926–1927, Le Corbusier

In his essay, *The Mathematics of the Ideal Villa*, 1947, Colin Rowe pointed out the similarity between the spatial subdivision of a Palladian villa and the structural grid of a villa by Le Corbusier. While both villas shared a similar proportioning system and a relationship to a higher mathematical order, Palladio's villa consisted of spaces with fixed shapes and harmonic interrelationships. Le Corbusier's villa was composed of horizontal layers of free space defined by the floor and roof slabs. The rooms varied in shape and were asymmetrically arranged at each level.



Villa Foscari, Malcontenta, Italy, 1558, Andrea Palladio

CLASSICAL ORDERS

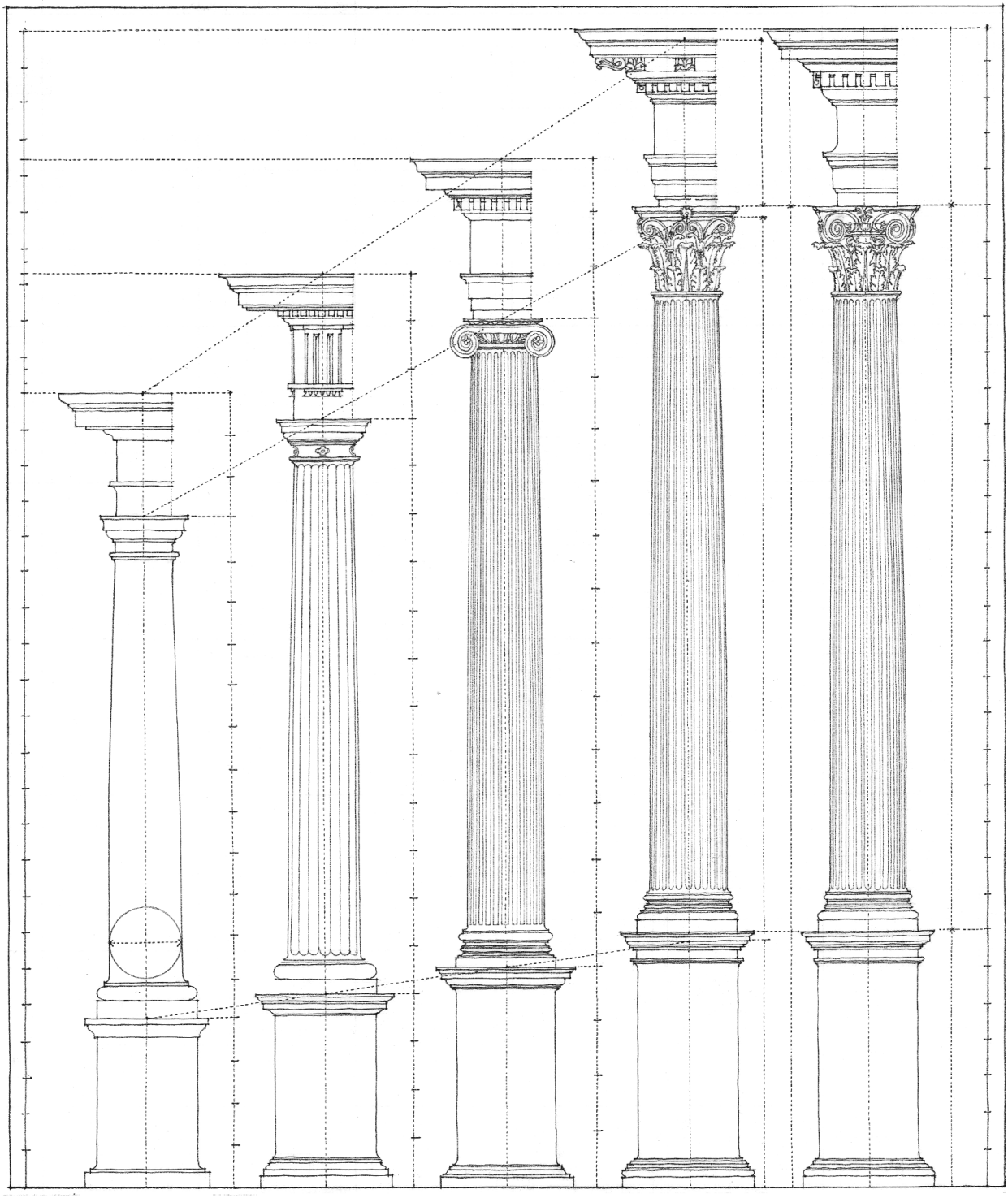


Ionic Order, from the **Temple on the Ilissus**, Athens, 449 B.C., Callicrates. After a drawing by William R. Ware.

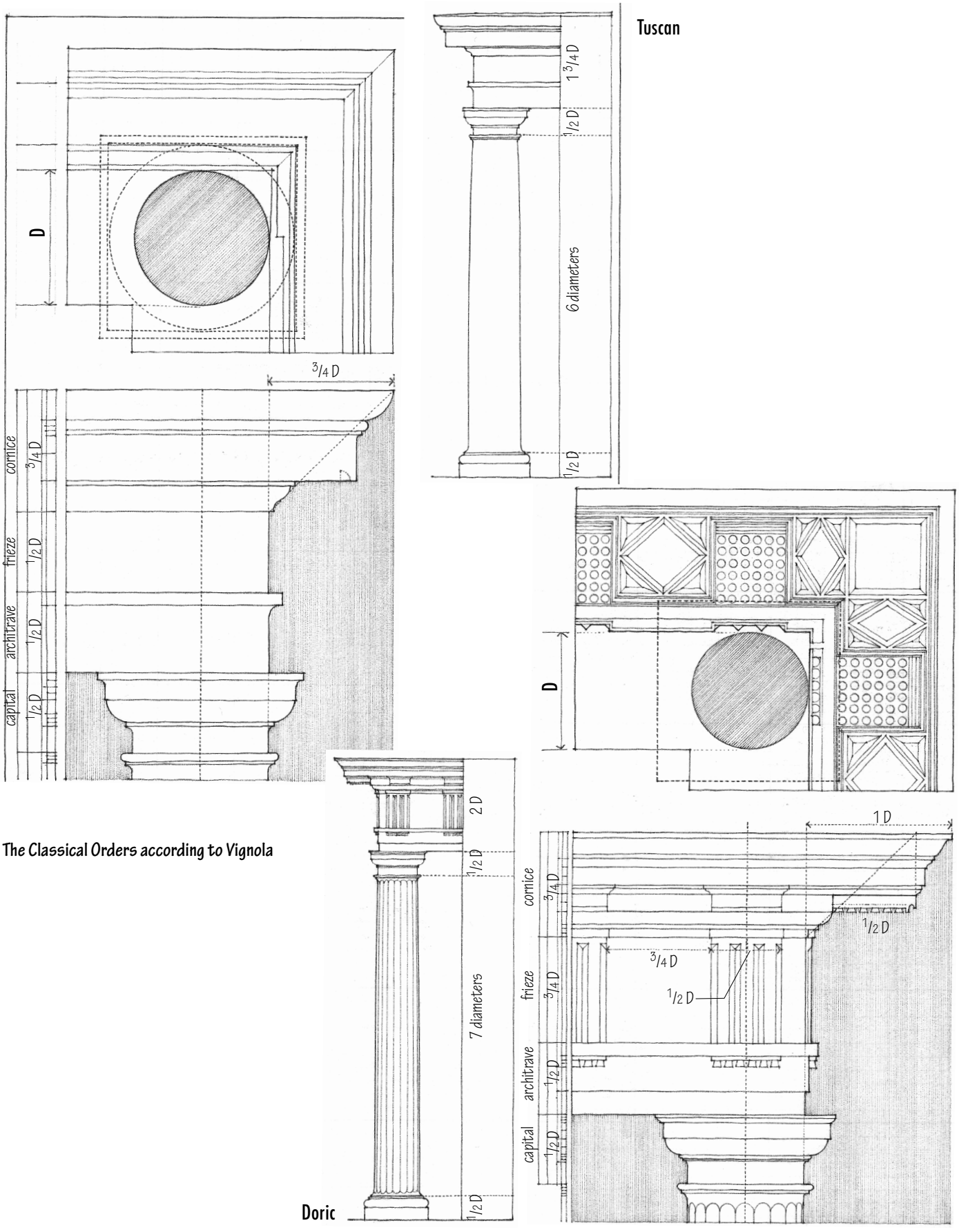
To the Greeks and Romans of classical antiquity, the Orders represented in their proportioning of elements the perfect expression of beauty and harmony. The basic unit of dimension was the diameter of the column. From this module were derived the dimensions of the shaft, the capital, as well as the pedestal below and the entablature above, down to the smallest detail. Intercolumniation—the system of spacing between columns—was also based on the diameter of the column.

Because the sizes of columns varied according to the extent of a building, the Orders were not based on a fixed unit of measurement. Rather, the intention was to ensure that all of the parts of any one building were proportionate and in harmony with one another.

Vitruvius, in the time of Augustus, studied actual examples of the Orders and presented his "ideal" proportions for each in his treatise, *The Ten Books on Architecture*. Vignola recodified these rules for the Italian Renaissance and his forms for the Orders are probably the best known today.

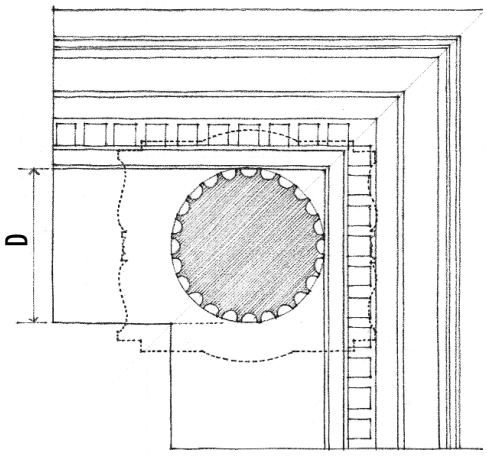

Tuscan
Doric
Ionic
Corinthian
Composite

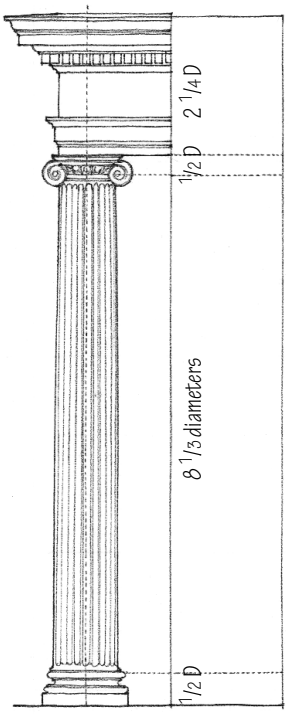
CLASSICAL ORDERS

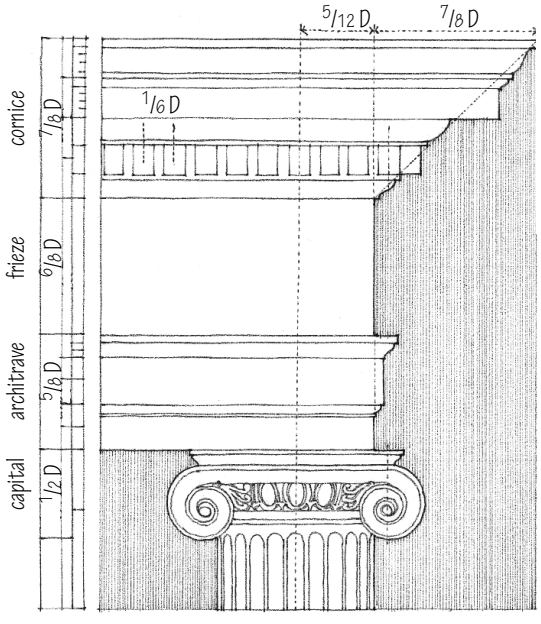


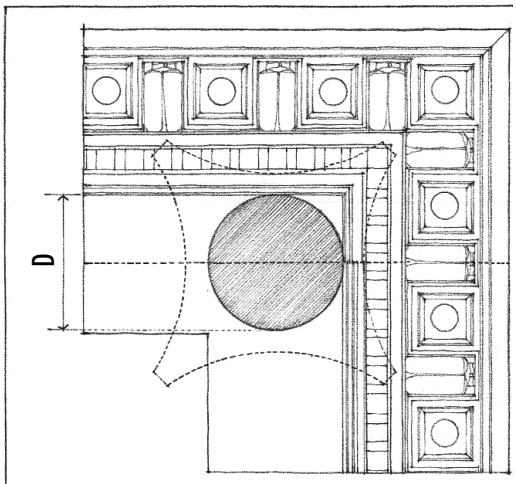
The Classical Orders according to Vignola

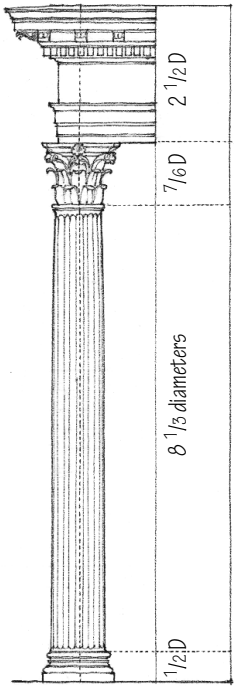
Ionic



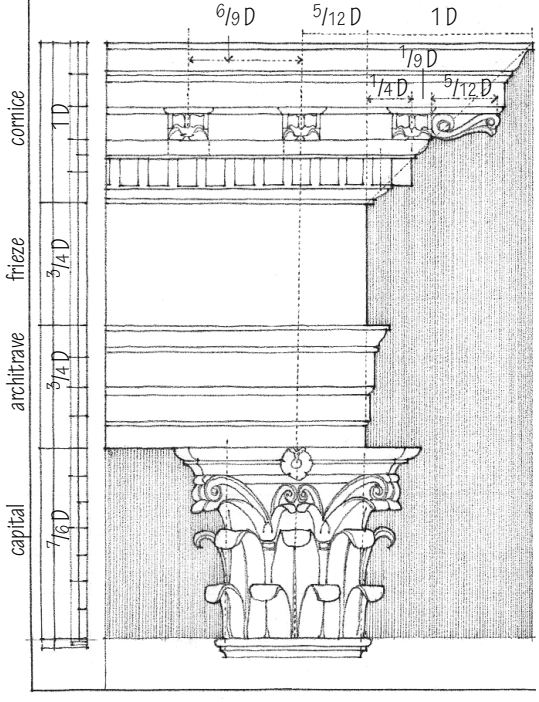




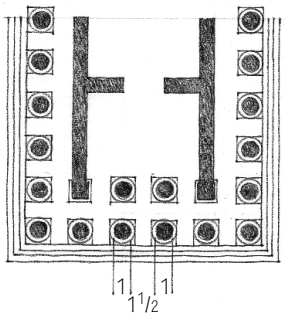




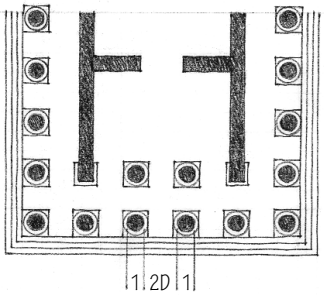
Corinthian



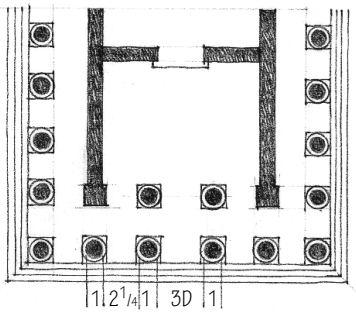
CLASSICAL ORDERS



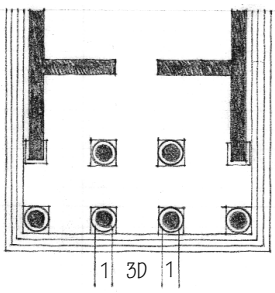
Pycnostyle



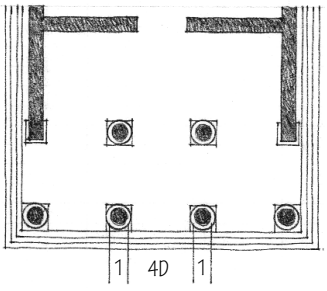
Systyle



Eustyle



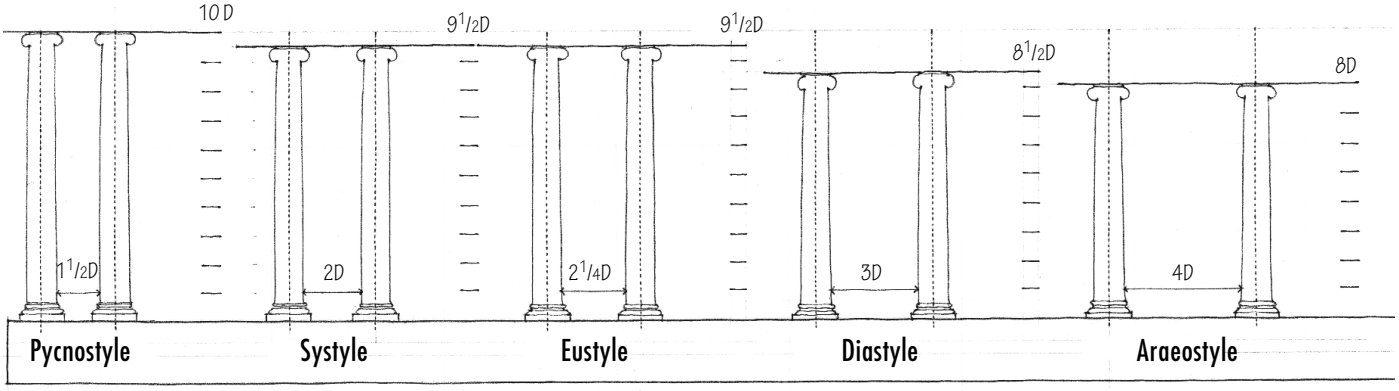
Diastyle

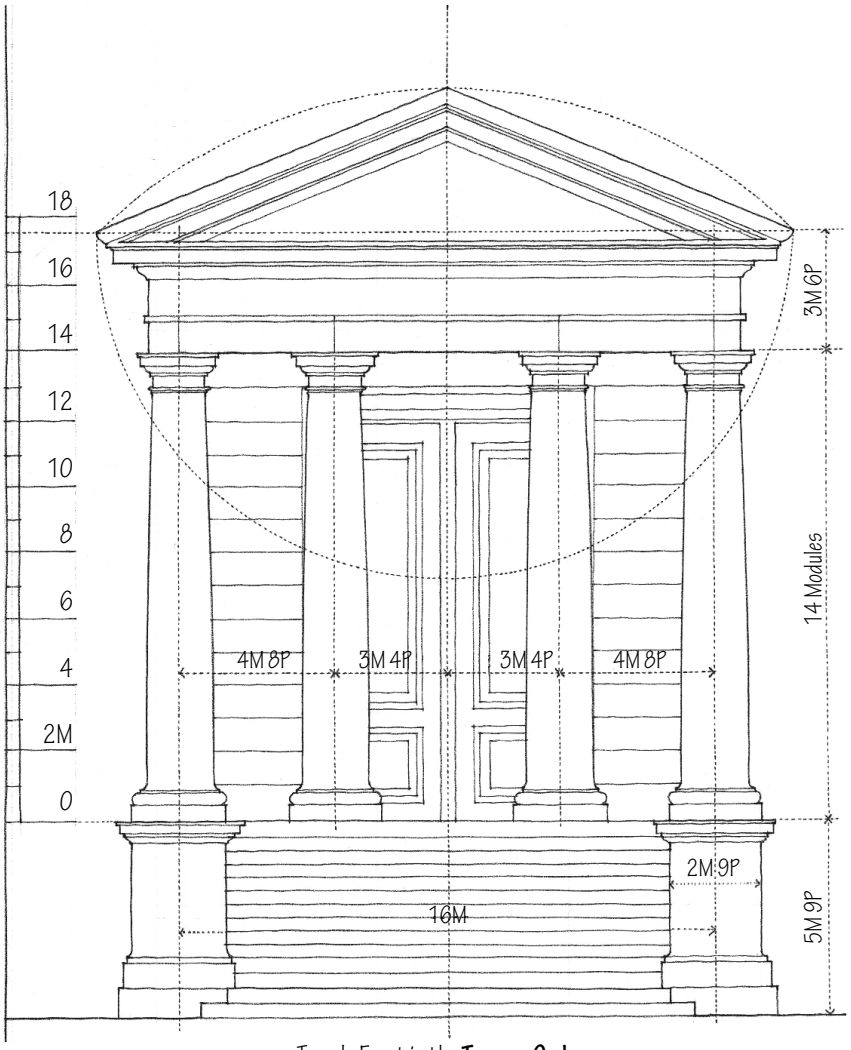


Araeostyle

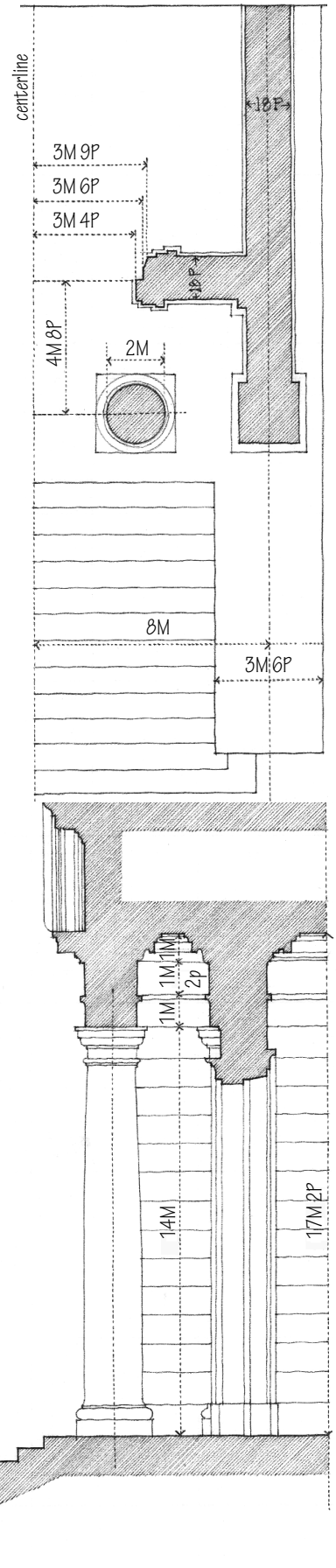
Classification of Temples according to their **Intercolumniation**

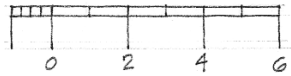
Vitruvius' Rules for the **Diameter, Height, and Spacing of Columns**

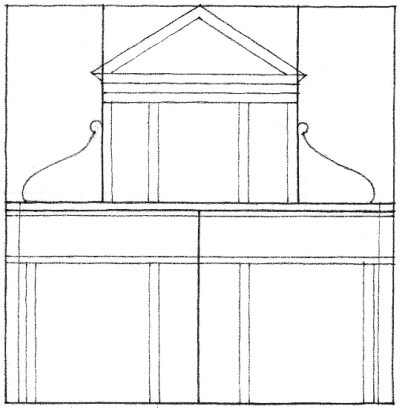


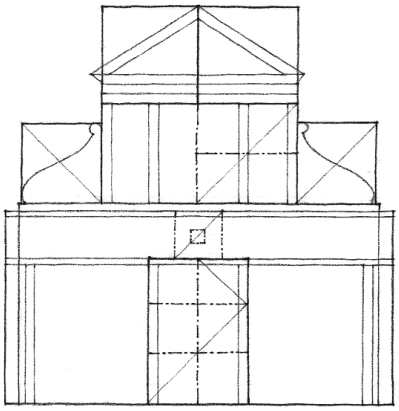


Temple Front in the **Tuscan Order**









St. Maria Novella, Florence, Italy.
Alberti designed the Renaissance facade (1456–1470) to complete a Gothic church (1278–1350).

Pythagoras discovered that the consonances of the Greek musical system could be expressed by the simple numerical progression—1, 2, 3, 4—and their ratios, 1:2, 1:3, 2:3, 3:4. This relationship led the Greeks to believe they had found the key to the mysterious harmony that pervaded the universe. The Pythagorean creed was "Everything is arranged according to numbers." Plato later developed Pythagoras' aesthetics of numbers into an aesthetics of proportion. He squared and cubed the simple numerical progression to produce the double and triple progressions, 1, 2, 4, 8, and 1, 3, 9, 27. For Plato, these numbers and their ratios not only contained the consonances of the Greek musical scale but also expressed the harmonic structure of his universe.

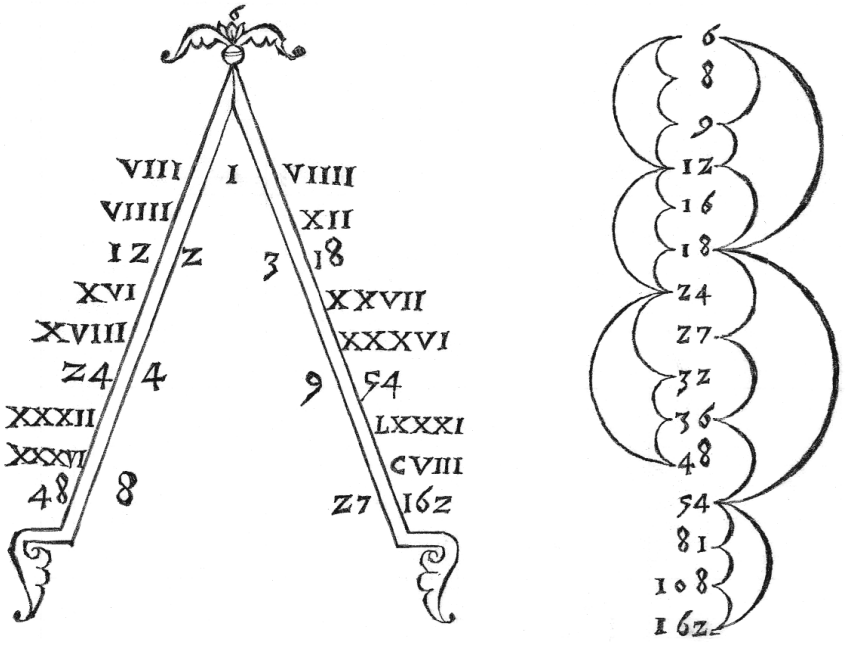
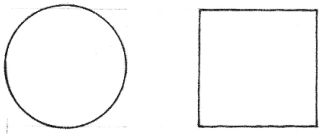


Diagram by Francesco Giorgi, 1525, illustrating the series of interlocking ratios that results from applying Pythagoras' theory of means to the intervals of the Greek musical scale.

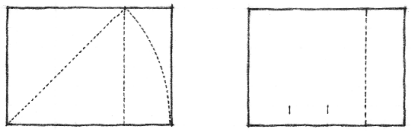
The architects of the Renaissance, believing that their buildings had to belong to a higher order, returned to the Greek mathematical system of proportions. Just as the Greeks conceived music to be geometry translated into sound, Renaissance architects believed that architecture was mathematics translated into spatial units. Applying Pythagoras' theory of means to the ratios of the intervals of the Greek musical scale, they developed an unbroken progression of ratios that formed the basis for the proportions of their architecture. These series of ratios manifested themselves not only in the dimensions of a room or a facade, but also in the interlocking proportions of a sequence of spaces or an entire plan.



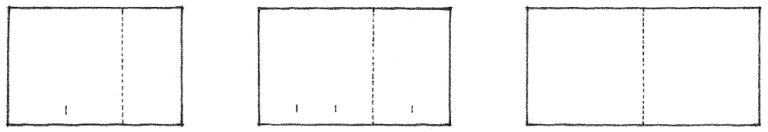
Circle Square

Seven Ideal Plan Shapes for Rooms.

Andrea Palladio (1508–1580) was probably the most influential architect of the Italian Renaissance. In *The Four Books on Architecture*, first published in Venice in 1570, he followed in the footsteps of his predecessors, Alberti and Serlio, and proposed these seven "most beautiful and proportionable manners of rooms."



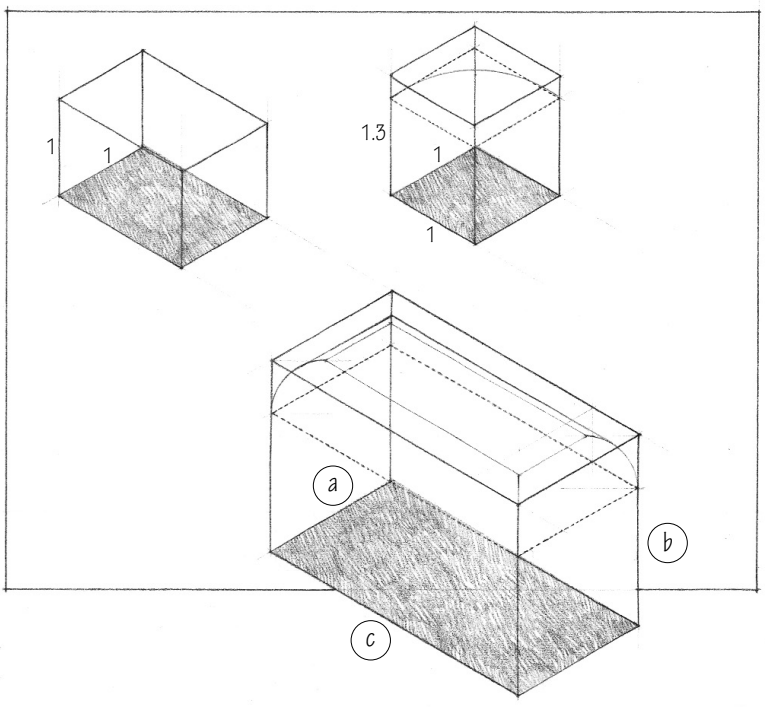
1:$\sqrt{2}$ 3:4



2:3 3:5 1:2

Determining the Heights of Rooms.

Palladio also proposed several methods for determining the height of a room so that it would be in proper proportion to the room's width and length. The height of rooms with flat ceilings would be equal to their width. The height of square rooms with vaulted ceilings would be one-third greater than their width. For other rooms, Palladio used Pythagoras' theory of means to determine their heights. Accordingly, there were three types of means: arithmetic, geometric, and harmonic.



Arithmetic:

$$\frac{c-b}{b-a} = \frac{c}{c} \text{ (e.g., 1, 2, 3 . . . or 6, 9, 12)}$$

Geometric:

$$\frac{c-b}{b-a} = \frac{c}{b} \text{ (e.g., 1, 2, 4 . . . or 4, 6, 9)}$$

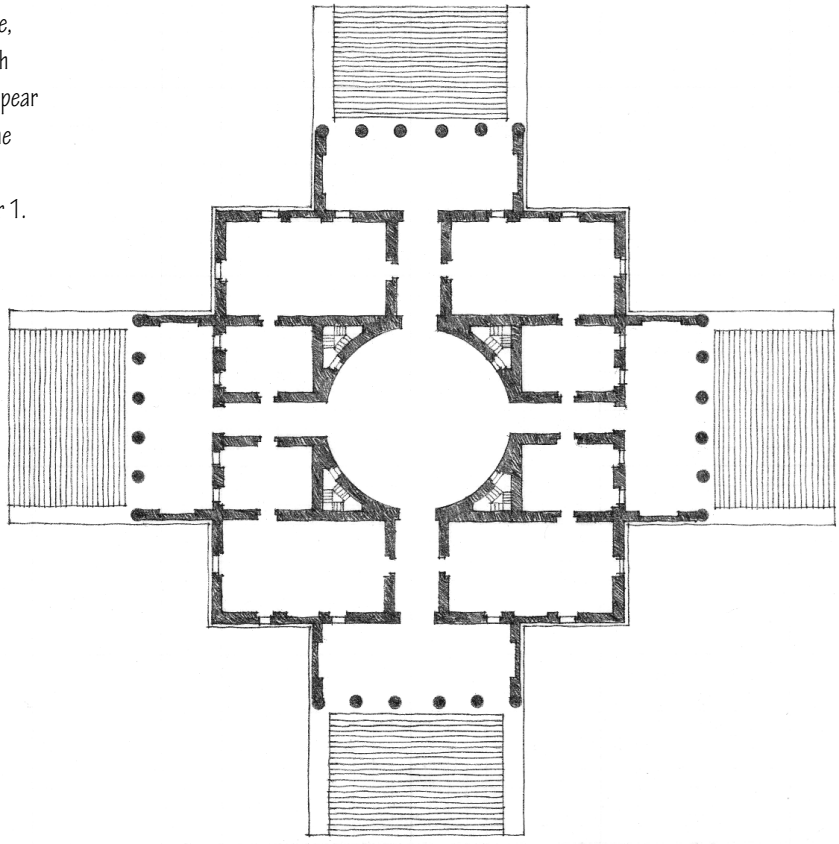
Harmonic:

$$\frac{c-b}{b-a} = \frac{c}{a} \text{ (e.g., 2, 3, 6 . . . or 6, 8, 12)}$$

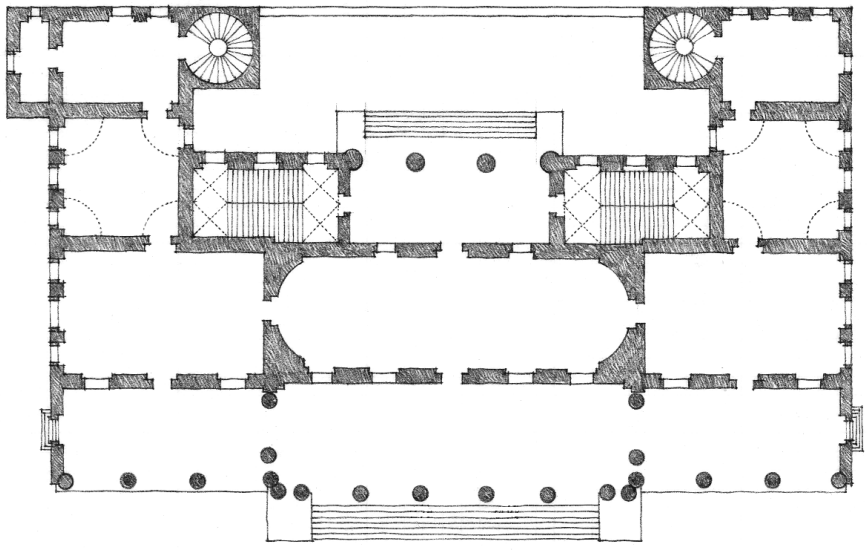
In each case, the height of a room is equal to the mean (b) between the two extremes of the width (a) and length (c) of the room.

RENAISSANCE THEORIES

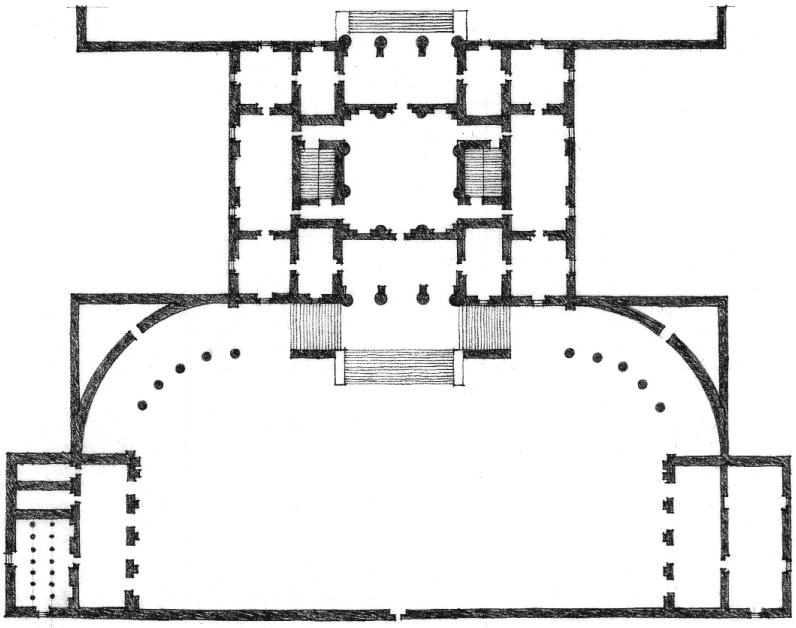
"Beauty will result from the form and correspondence of the whole, with respect to the several parts, of the parts with regard to each other, and of these again to the whole; that the structure may appear an entire and complete body, wherein each member agrees with the other, and all necessary to compose what you intend to form."
—Andrea Palladio, *The Four Books on Architecture*, Book I, Chapter 1.



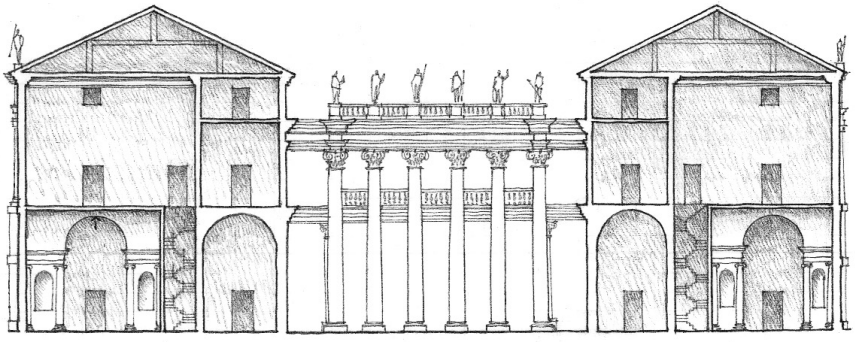
Villa Capra (The Rotunda), Vicenza, Italy, 1552–1567, Andrea Palladio
12 × 30, 6 × 15, 30 × 30

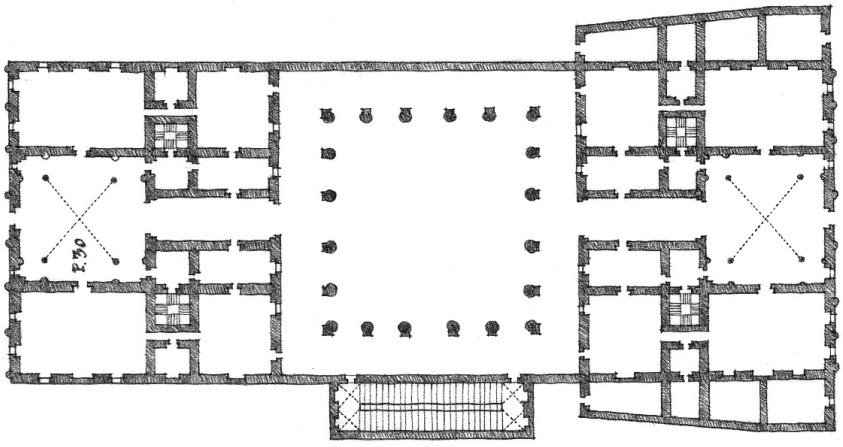


Palazzo Chiericati, Vicenza, Italy, 1550, Andrea Palladio
54 × 16 (18), 18 × 30, 18 × 18, 18 × 12



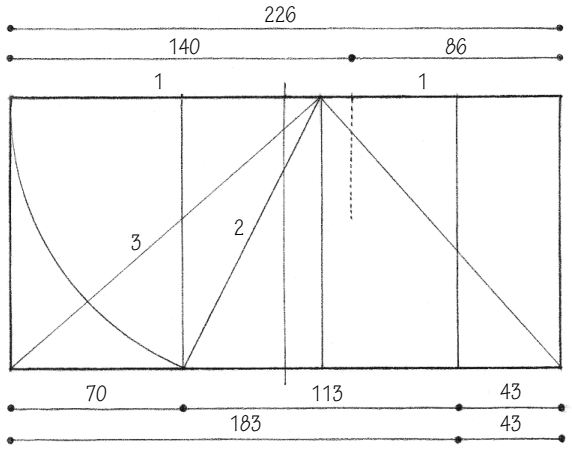
Villa Thiene, Cicogna, Italy, 1549, Andrea Palladio
18 × 36, 36 × 36, 36 × 18, 18 × 18, 18 × 12





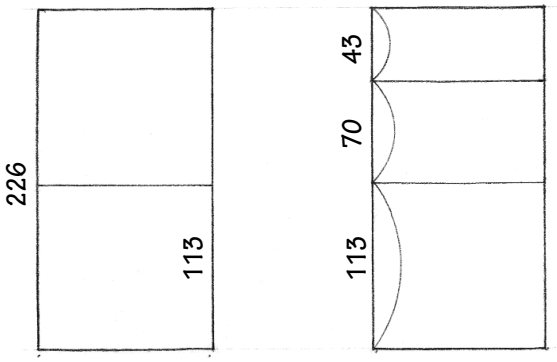
Palazzo Iseppo Porto, Vicenza, Italy, 1552, Andrea Palladio
30 × 30, 20 × 30, 10 × 30, 45 × 45

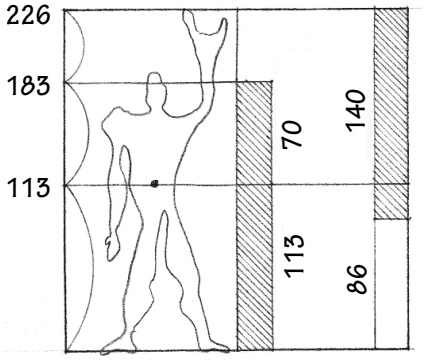
MODULOR



Le Corbusier developed his proportioning system, the Modulor, to order "the dimensions of that which contains and that which is contained." He saw the measuring tools of the Greeks, Egyptians, and other high civilizations as being "infinitely rich and subtle because they formed part of the mathematics of the human body, gracious, elegant, and firm, the source of that harmony which moves us, beauty." He therefore based his measuring tool, the Modulor, on both mathematics (the aesthetic dimensions of the Golden Section and the Fibonacci Series), and the proportions of the human body (functional dimensions).

Le Corbusier began his study in 1942, and published *The Modulor: A Harmonious Measure to the Human Scale Universally Applicable to Architecture and Mechanics* in 1948. A second volume, *Modulor II*, was published in 1954.

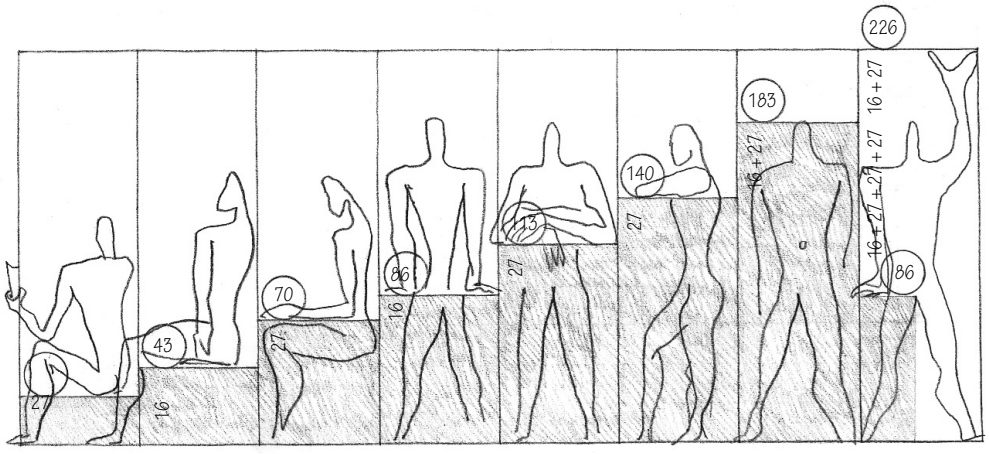


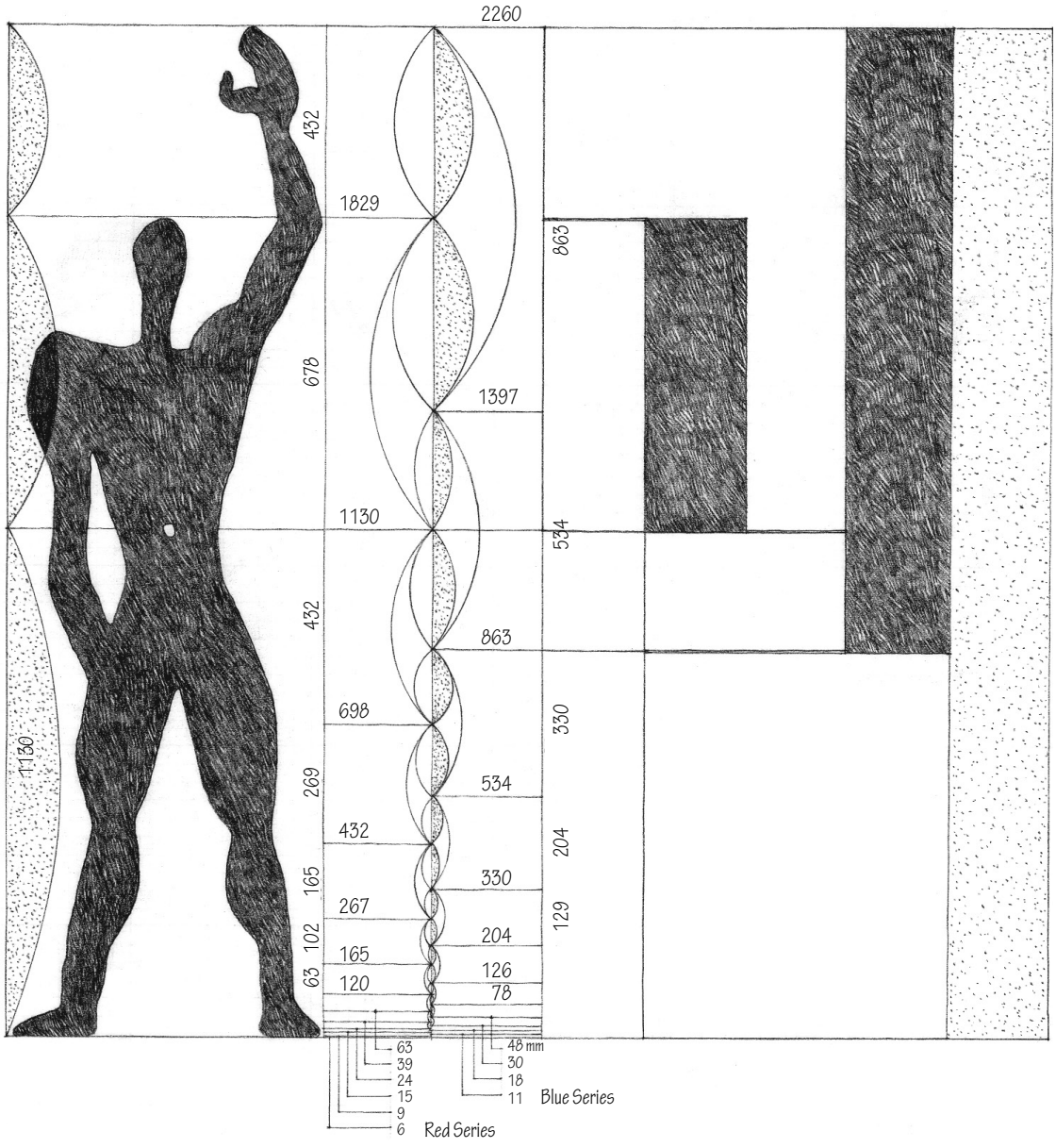


The basic grid consists of three measures, 113, 70, and 43 centimeters, proportioned according to the Golden Section.

43 + 70 = 113
113 + 70 = 183
113 + 70 + 43 = 226 (2 × 113)

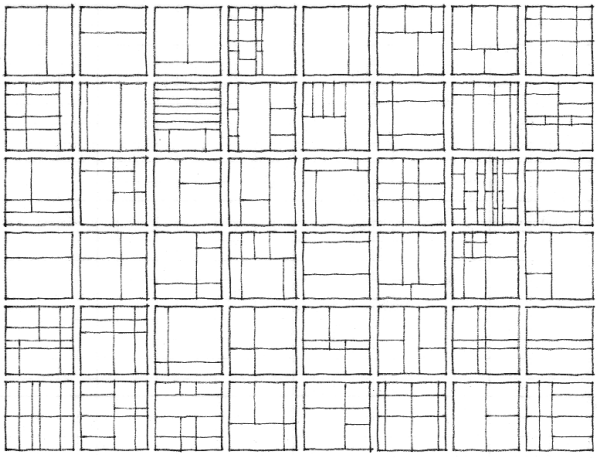
113, 183, and 226 define the space occupied by the human figure. From 113 and 226, Le Corbusier developed the Red and Blue series, diminishing scales of dimensions that were related to the stature of the human figure.

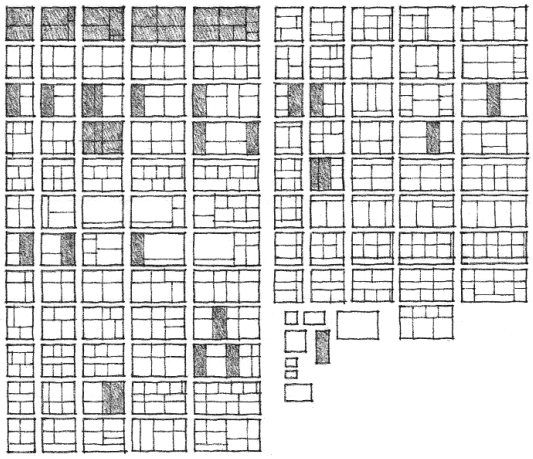


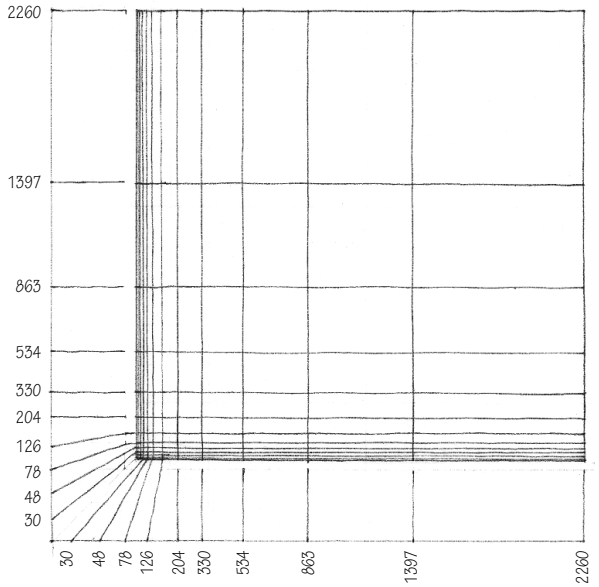


Le Corbusier saw the Modulor not merely as a series of numbers with an inherent harmony, but as a system of measurements that could govern lengths, surfaces, and volumes, and "maintain the human scale everywhere." It could "lend itself to an infinity of combinations; it ensures unity with diversity . . . the miracle of numbers."

MODULOR

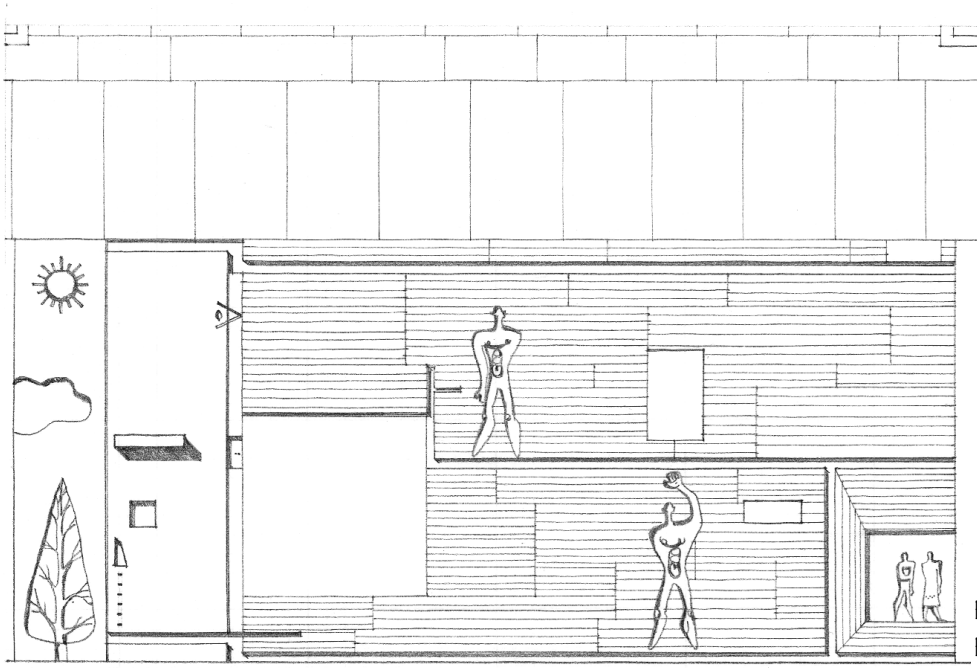




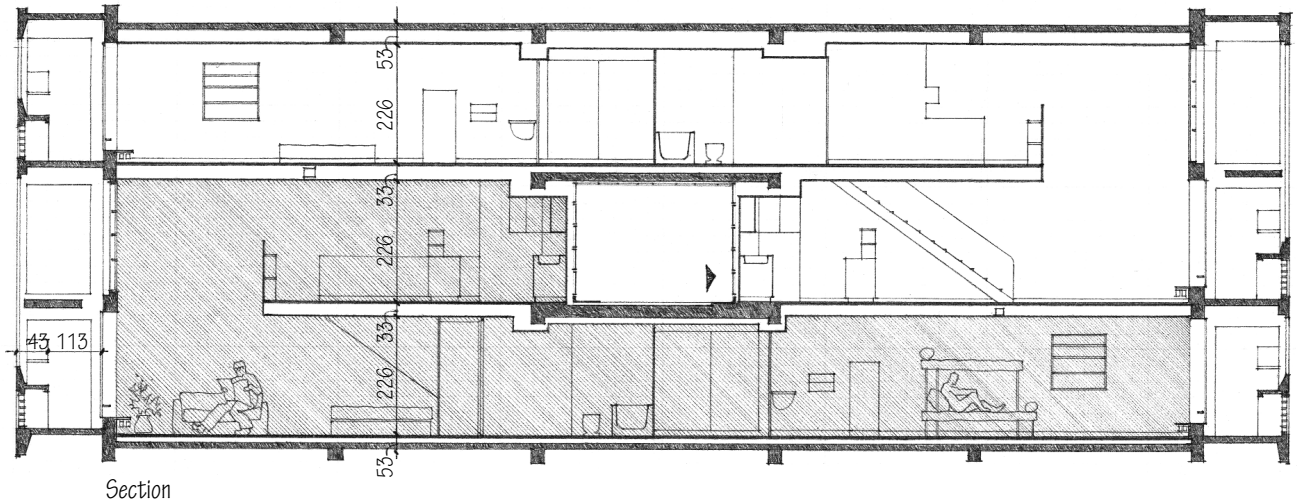


The principal work of Le Corbusier that exemplified the use of the Modulor was his Unité d'Habitation at Marseilles. It uses 15 measures of the Modulor to bring human scale to a building that is 140 meters long, 24 meters wide, and 70 meters high.

Le Corbusier used these diagrams to illustrate the diversity of panel sizes and surfaces that could be obtained with the proportions of the Modulor.

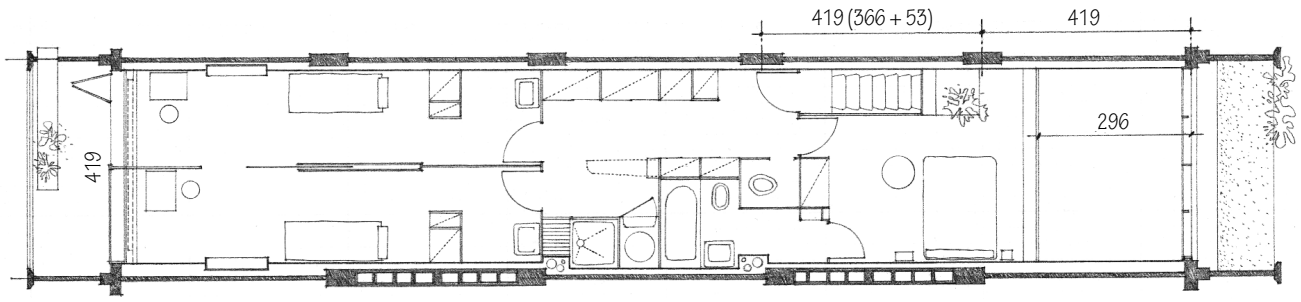


Facade Detail, **Unité d'Habitation**, Firminy-Vert, France, 1965–1968, Le Corbusier

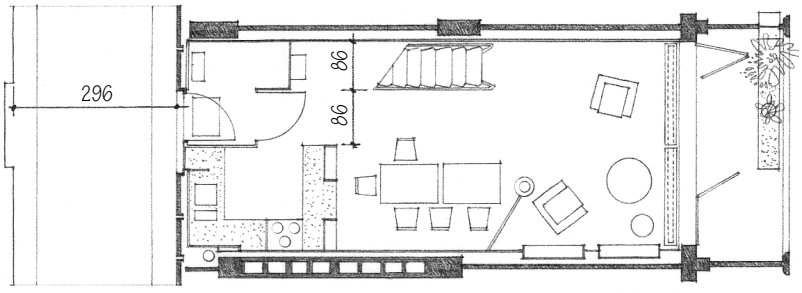


Section

Typical Apartment Unit,
Unité d'Habitation, Marseilles, 1946–1952, Le Corbusier

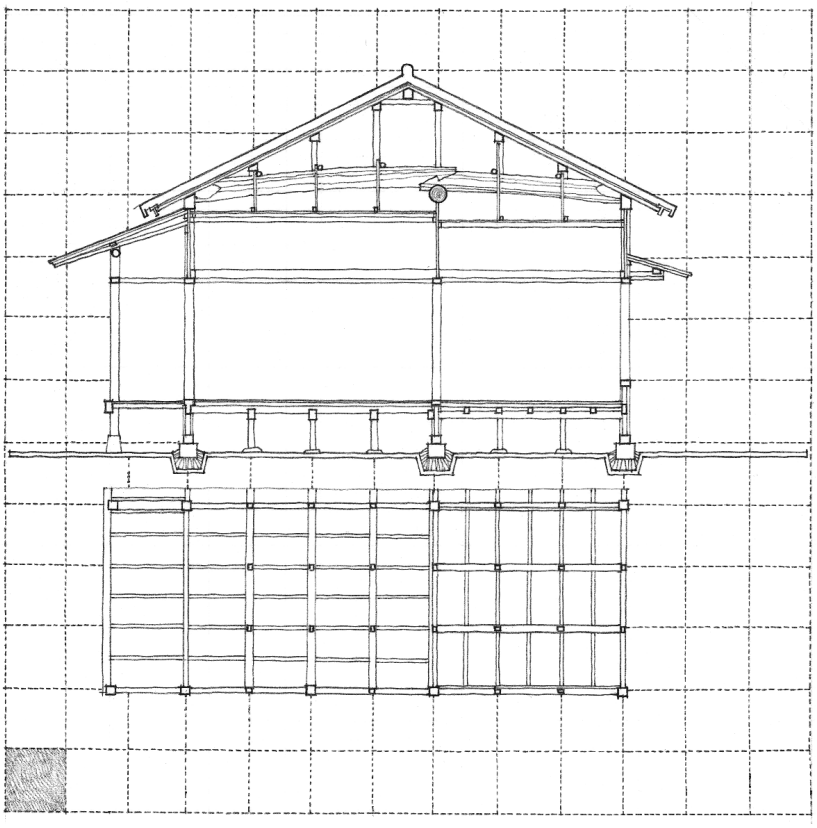


Main floor plan



Lower floor plan

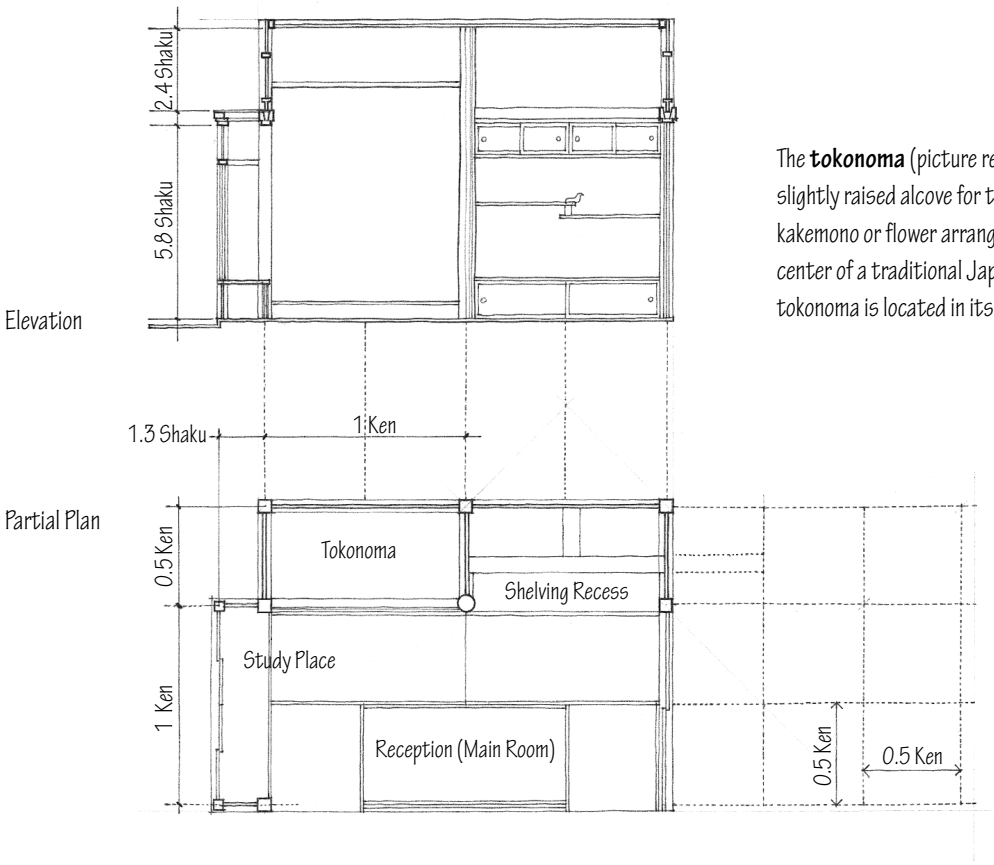
KEN



Traditional Japanese House

The traditional Japanese unit of measure, the shaku, was originally imported from China. It is almost equivalent to the English foot and divisible into decimal units. Another unit of measure, the ken, was introduced in the latter half of Japan's Middle Ages. Although it was originally used simply to designate the interval between two columns and varied in size, the ken was soon standardized for residential architecture. Unlike the module of the Classical Orders, which was based on the diameter of a column and varied with the size of a building, the ken became an absolute measurement.

The ken, however, was not only a measurement for the construction of buildings. It evolved into an aesthetic module that ordered the structure, materials, and space of Japanese architecture.



The **tokonoma** (picture recess) is a shallow, slightly raised alcove for the display of a kakemono or flower arrangement. As the spiritual center of a traditional Japanese house, the tokonoma is located in its most formal room.

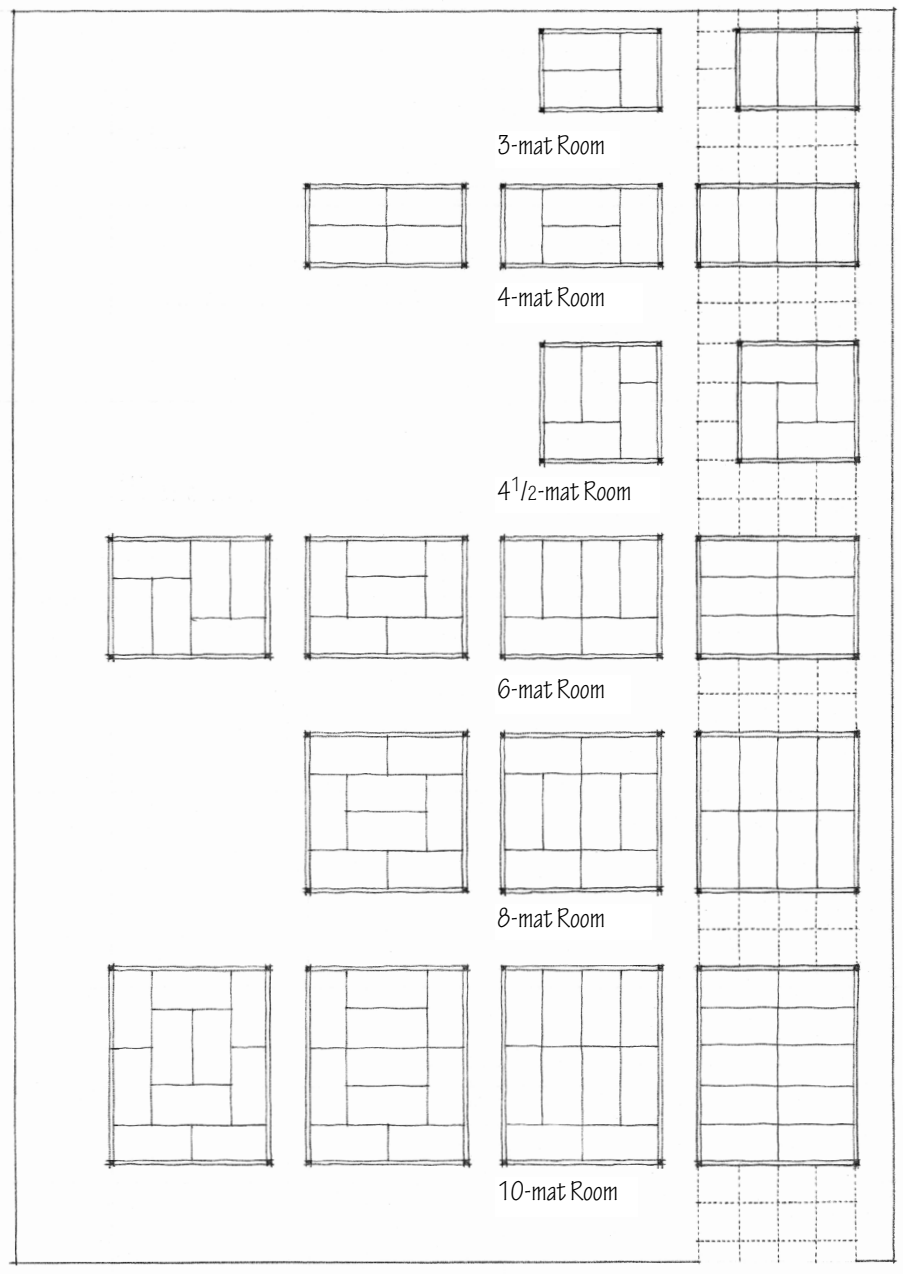
Two methods of designing with the ken modular grid developed that affected its dimension. In the Inaka-ma method, the ken grid of 6 shaku determined the center-to-center spacing of columns. Therefore, the standard tatami floor mat (3 × 6 shaku or 0.5 × 1 ken) varied slightly to allow for the thickness of the columns.

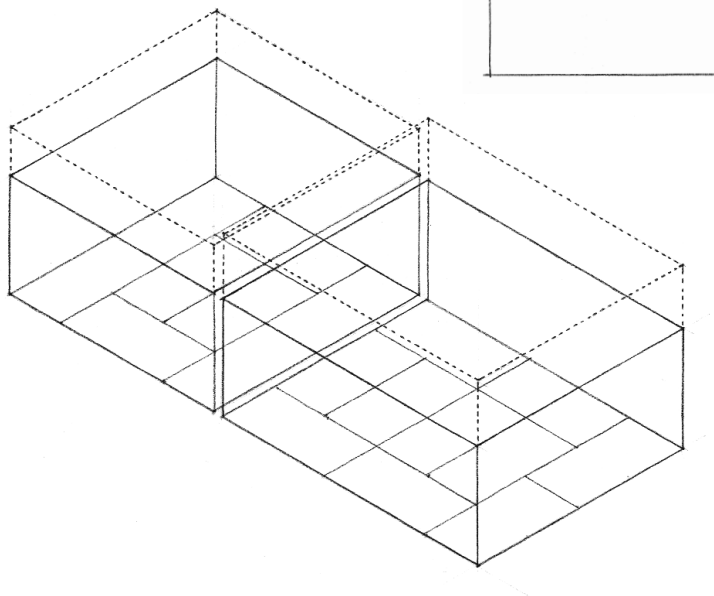
In the Kyo-ma method, the floor mat remained constant (3.15 × 6.30 shaku) and the column spacing (ken module) varied according to the size of the room and ranged from 6.4 to 6.7 shaku.

The size of a room is designated by the number of its floor mats. The traditional floor mat was originally proportioned to accommodate two persons sitting or one person sleeping. As the ordering system of the ken grid developed, however, the floor mat lost its dependence on human dimensions and was subjected to the demands of the structural system and its column spacing.

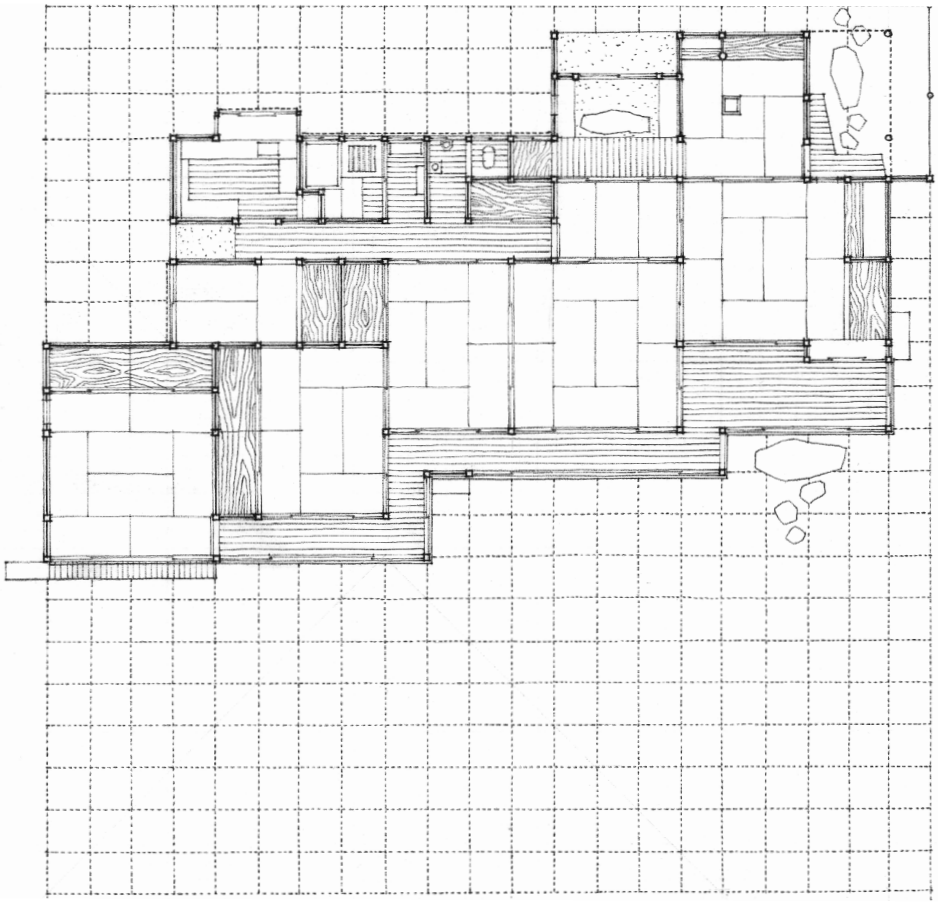
Because of their 1:2 modularity, the floor mats can be arranged in a number of ways for any given room size. And for each room size, a different ceiling height is established according to the following:

height of the ceiling (shaku), measured from the top of the frieze board = number of mats × 0.3.

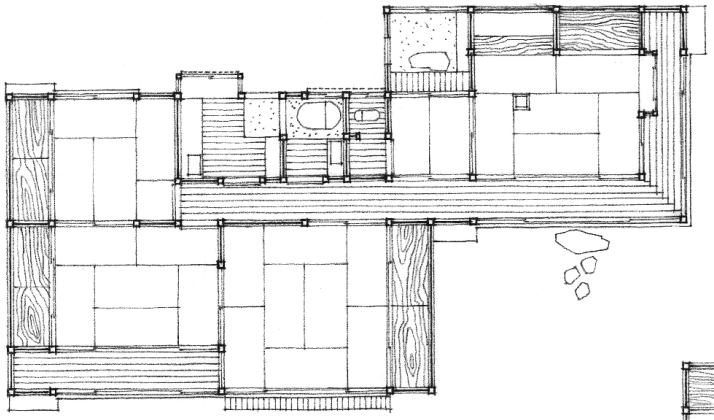


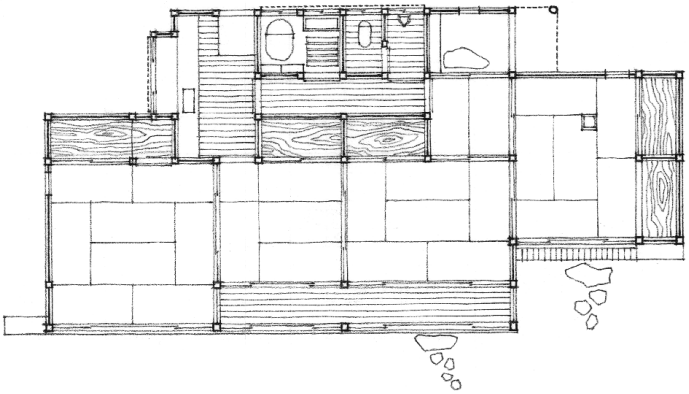


KEN

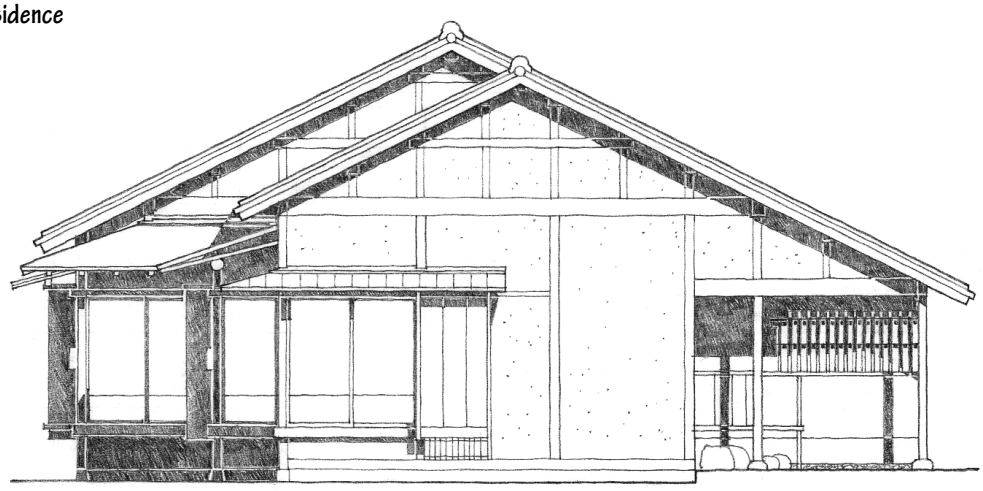


In a typical Japanese residence, the ken grid orders the structure as well as the additive, space-to-space sequence of rooms. The relatively small size of the module allows the rectangular spaces to be freely arranged in linear, staggered, or clustered patterns.

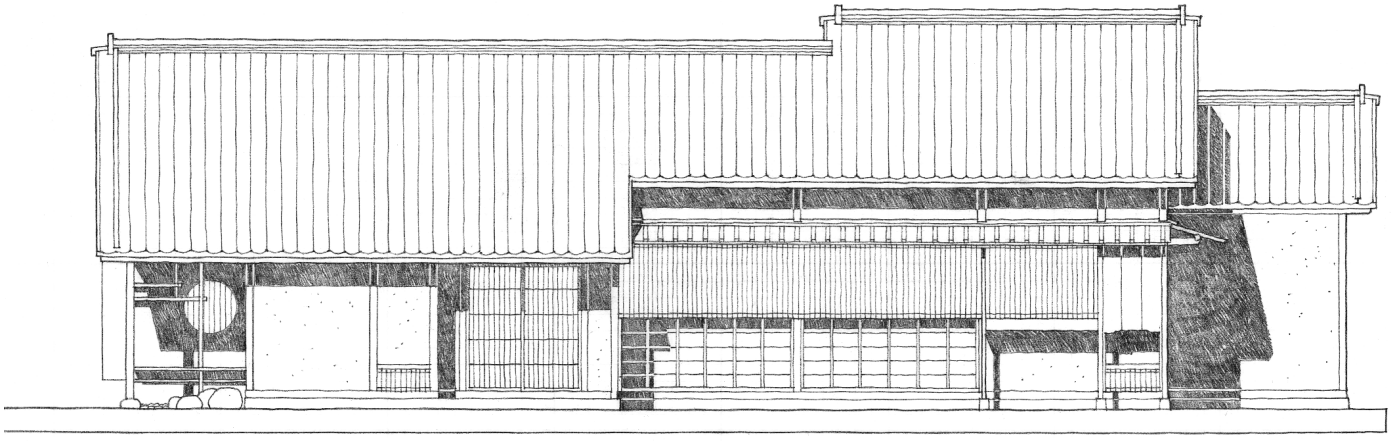




Elevations of a Traditional Japanese Residence

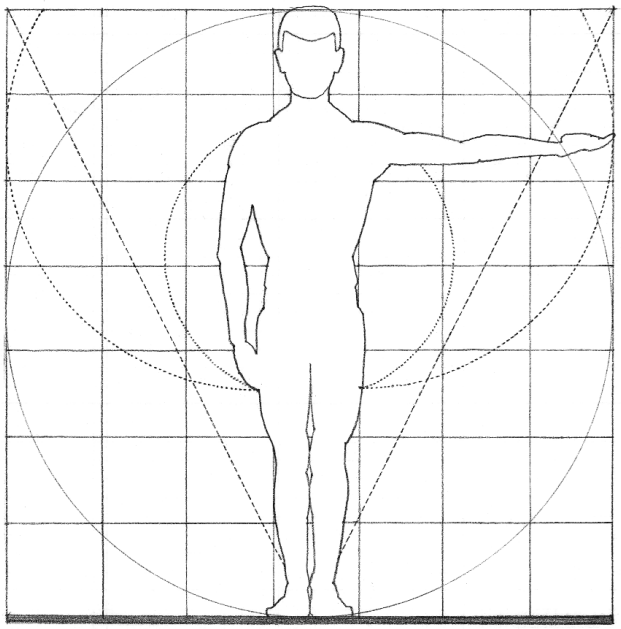


East Elevation



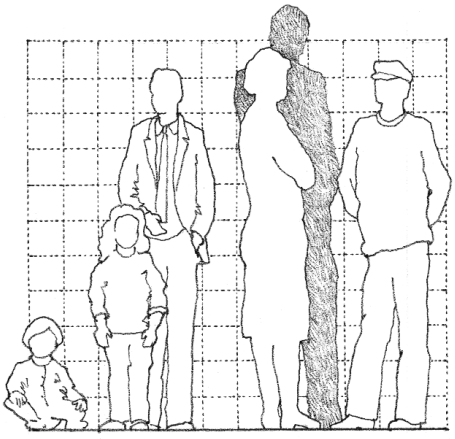
North Elevation

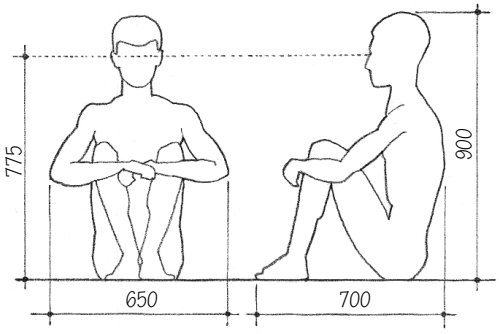
ANTHROPOMETRY

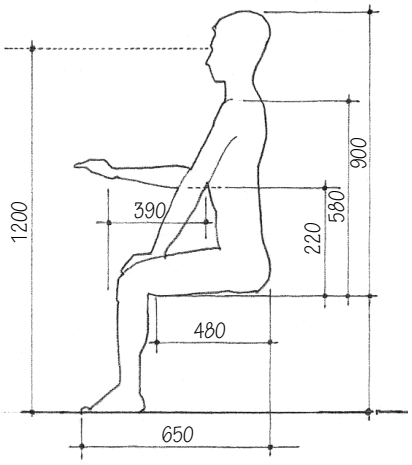


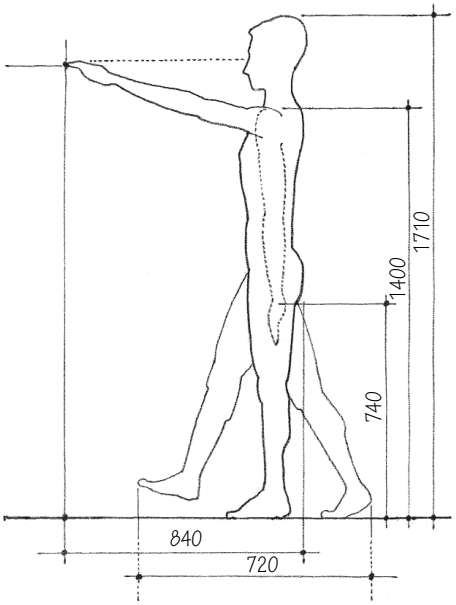
Anthropometry refers to the measurement of the size and proportions of the human body. While the architects of the Renaissance saw the proportions of the human figure as a reaffirmation that certain mathematical ratios reflected the harmony of their universe, anthropometric proportioning methods seek not abstract or symbolic ratios, but functional ones. They are predicated on the theory that forms and spaces in architecture are either containers or extensions of the human body and should therefore be determined by its dimensions.

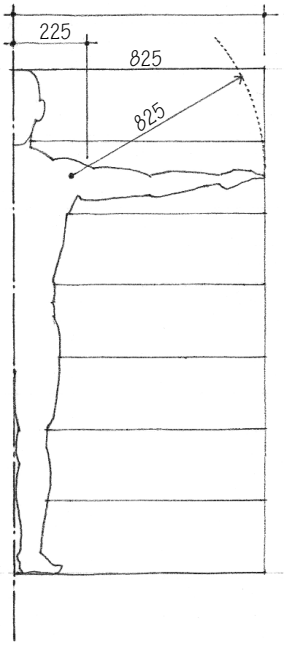
The difficulty with anthropometric proportioning is the nature of the data required for its use. For example, the dimensions given here in millimeters are average measurements and are merely guidelines that should be modified to satisfy specific user needs. Average dimensions must always be treated with caution since variations from the norm will always exist due to the difference between men and women, among various age and racial groups, even from one individual to the next.





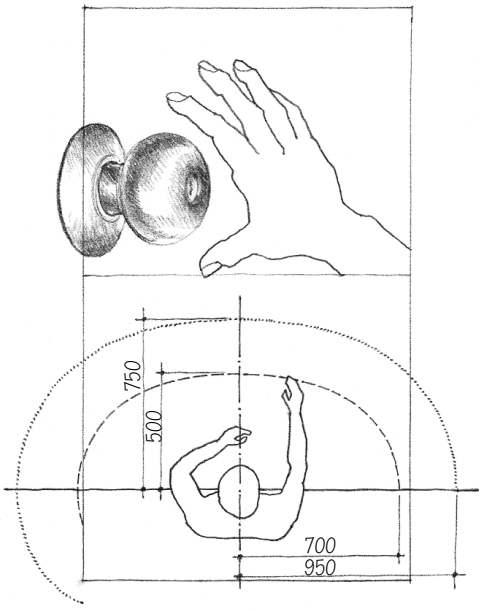


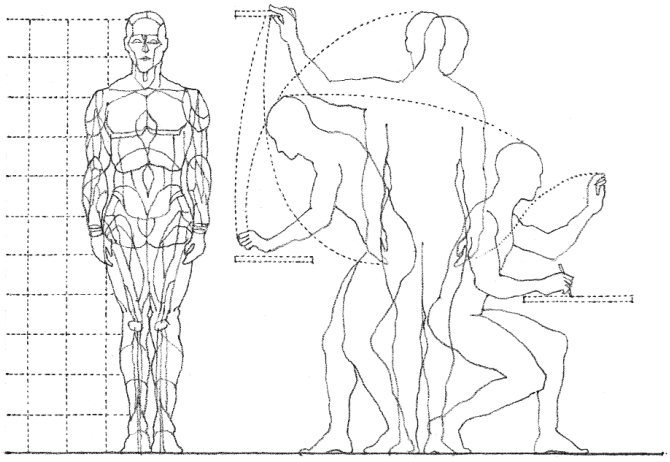


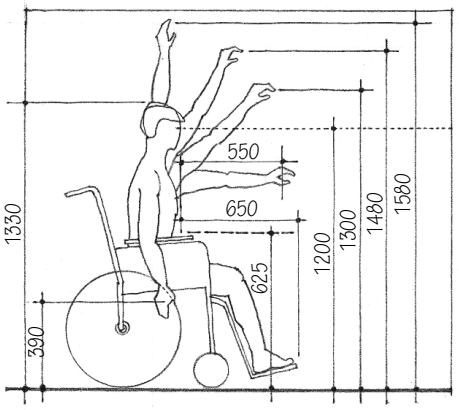


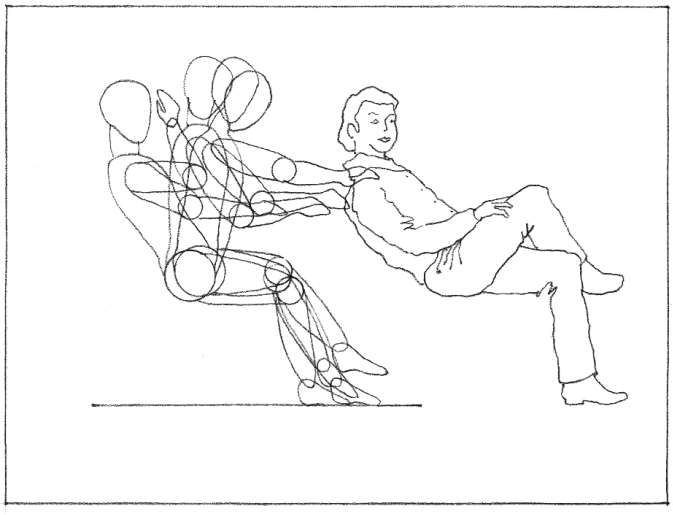
The dimensions and proportions of the human body affect the proportion of things we handle, the height and distance of things we try to reach, and the dimensions of the furnishings we use for sitting, working, eating, and sleeping. There is a difference between our structural dimensions and those dimensional requirements that result from how we reach for something on a shelf, sit down at a table, walk down a set of stairs, or interact with other people. These are functional dimensions and will vary according to the nature of the activity engaged in and the social situation.

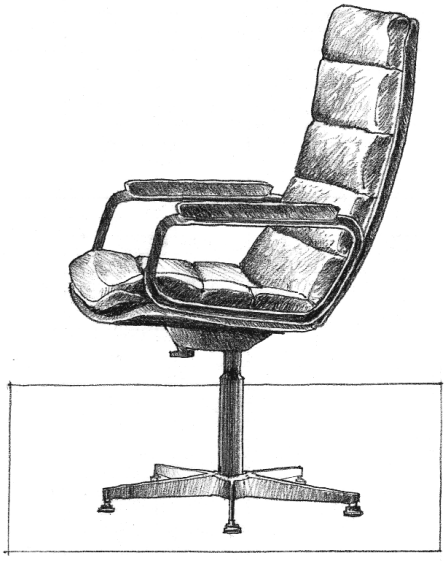
A special field that has developed from a concern with human factors is ergonomics—the applied science that coordinates the design of devices, systems, and environments with our physiological and psychological capacities and requirements.



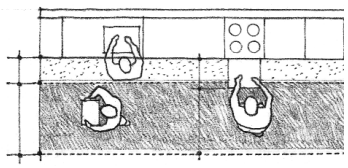


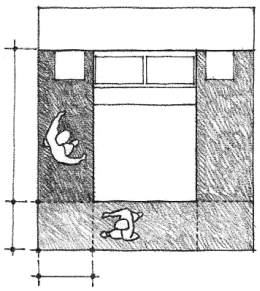




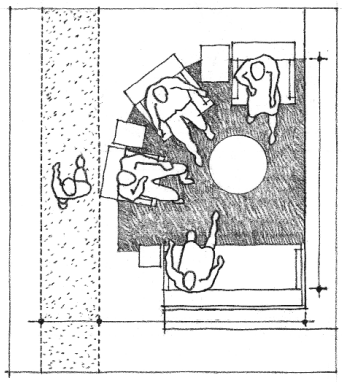


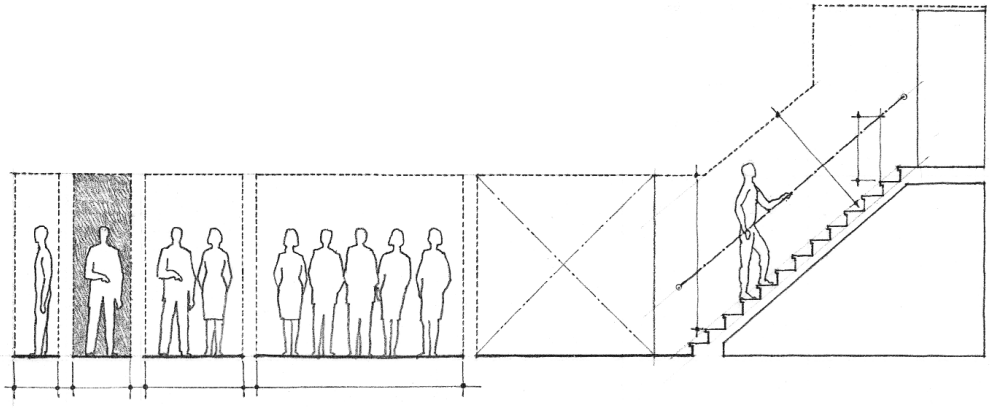
ANTHROPOMETRY

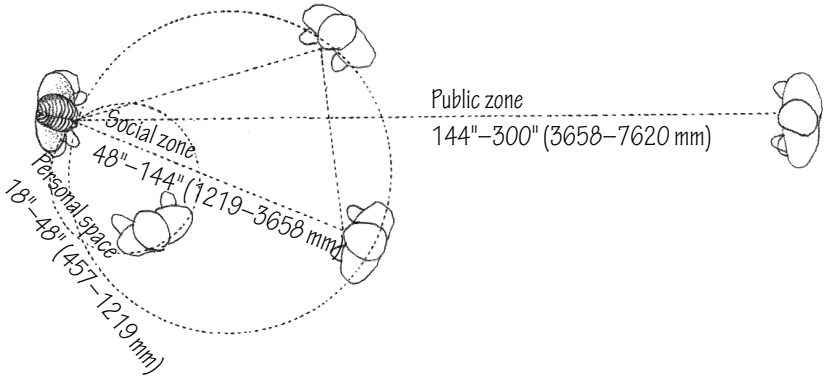


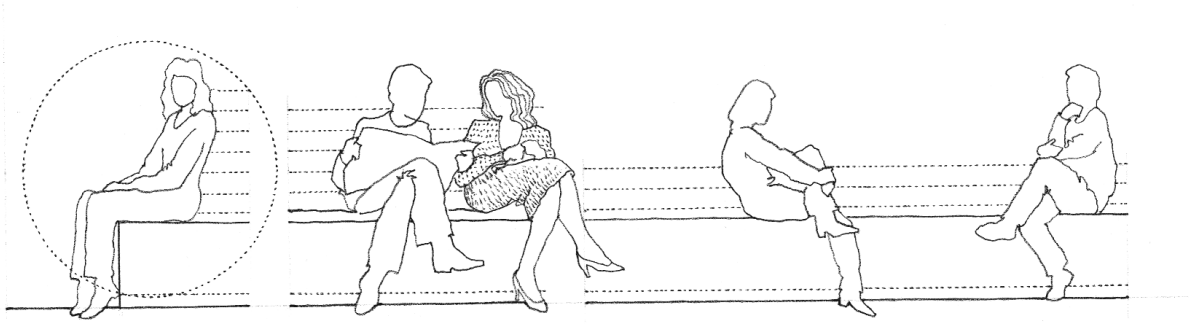


In addition to the elements that we use in a building, the dimensions of the human body also affect the volume of space we require for movement, activity, and rest. The fit between the form and dimensions of a space and our own body dimensions can be a static one as when we sit in a chair, lean against a railing, or nestle within an alcove space. There can also be a dynamic fit as when we enter a building's foyer, walk up a stairway, or move through the rooms and halls of a building. A third type of fit is how a space accommodates our need to maintain appropriate social distances and to have control over our personal space.



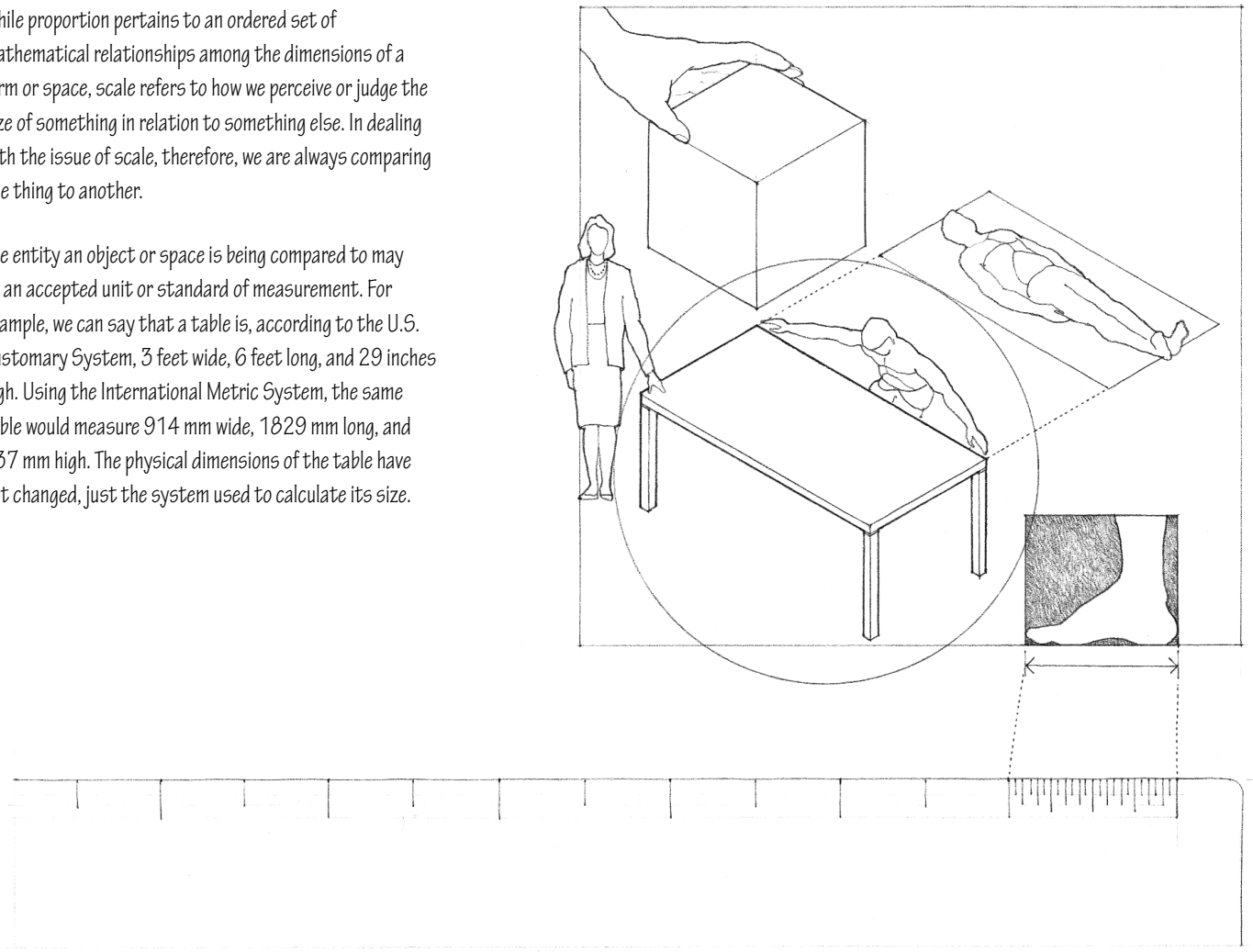




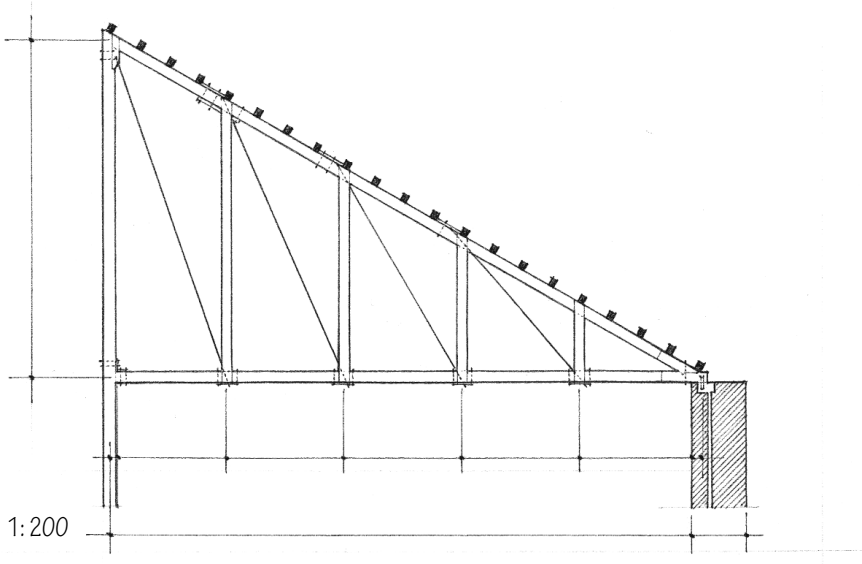


While proportion pertains to an ordered set of mathematical relationships among the dimensions of a form or space, scale refers to how we perceive or judge the size of something in relation to something else. In dealing with the issue of scale, therefore, we are always comparing one thing to another.

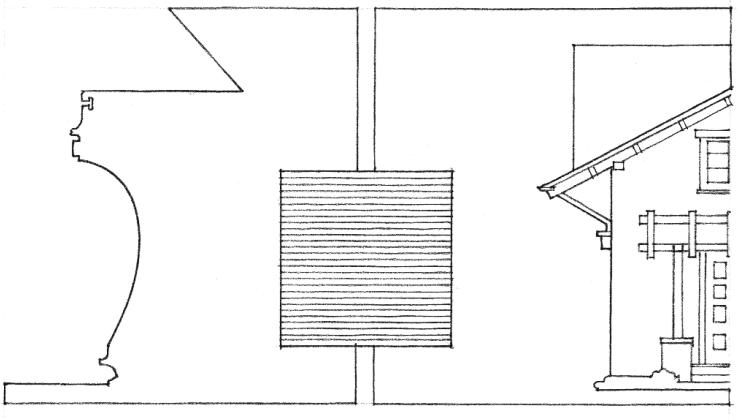
The entity an object or space is being compared to may be an accepted unit or standard of measurement. For example, we can say that a table is, according to the U.S. Customary System, 3 feet wide, 6 feet long, and 29 inches high. Using the International Metric System, the same table would measure 914 mm wide, 1829 mm long, and 737 mm high. The physical dimensions of the table have not changed, just the system used to calculate its size.



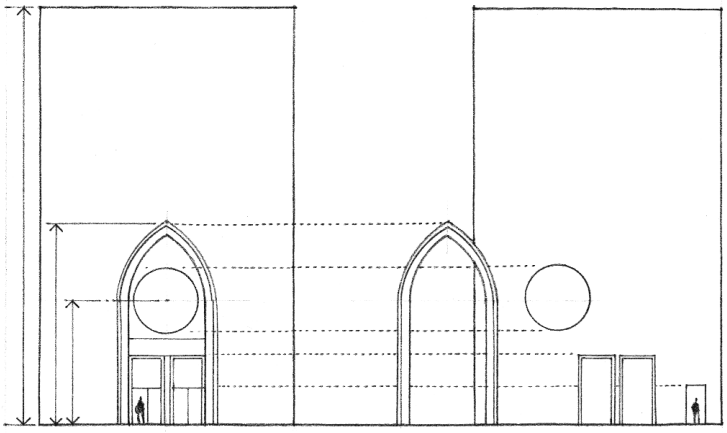
In drawing, we use a scale to specify the ratio that determines the relationship between an illustration to that which it represents. For example, the scale of an architectural drawing notes the size of a depicted building in comparison to the real thing.



VISUAL SCALE



How large is this square?



Mechanical scale: the size or proportion of something relative to an accepted standard of measurement.

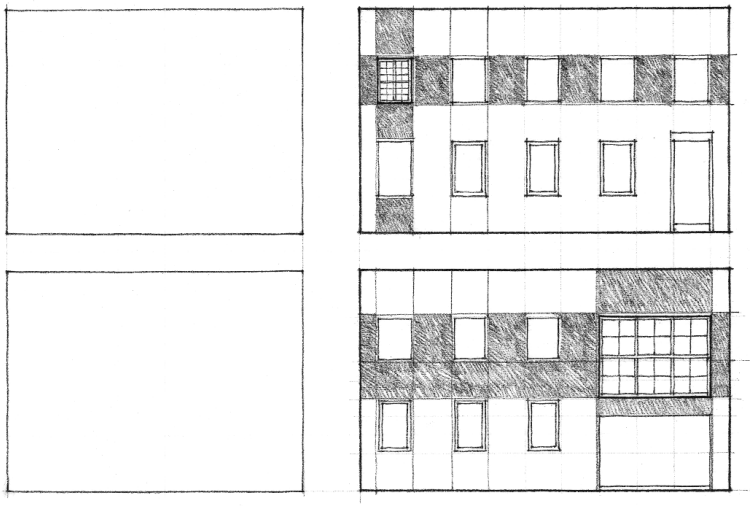
Visual scale: the size or proportion an element appears to have relative to other elements of known or assumed size.

Of particular interest to designers is the notion of visual scale, which refers not to the actual dimensions of things, but rather to how small or large something appears to be in relation to its normal size or to the size of other things in its context.

When we say something is small-scale or miniature, we usually mean that thing appears to be smaller than its usual size. Likewise, something that is large-scale is perceived as being larger than what is normal or expected.

We speak of urban scale when we refer to the size of a project in the context of a city, or neighborhood scale when we judge a building appropriate to its locale within a city, or street scale when we note the relative sizes of elements fronting a roadway.

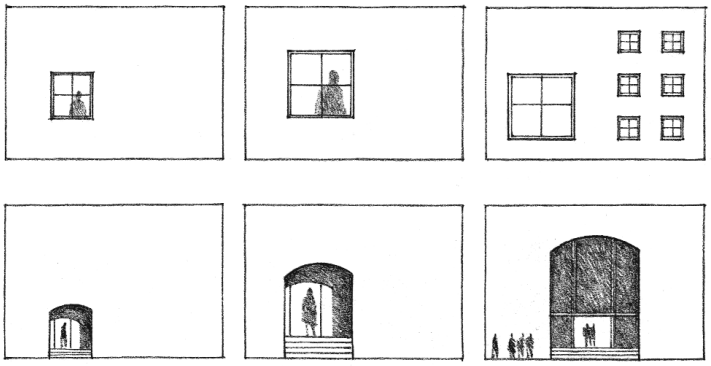
At the scale of a building, all elements, no matter how plain or unimportant they may be, have a certain size. Its dimensions may be predetermined by the manufacturer, or they may be selected by the designer from a range of choices. Nevertheless, we perceive the size of each element in relation to other parts or to the whole of a composition.



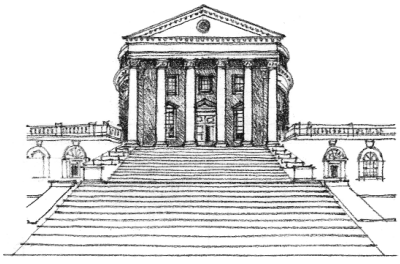
For example, the size and proportion of windows in a building facade are visually related to one another as well as to the spaces between them and the overall dimensions of the facade. If the windows are all of the same size and shape, they establish a scale relative to the size of the facade.

If, however, one of the windows is larger than the others, it would create another scale within the composition of the facade. The jump in scale could indicate the size or significance of the space behind the window, or it could alter our perception of the size of the other windows or the overall dimensions of the facade.

Many building elements have sizes and characteristics that are familiar to us and which we use to gauge the sizes of other elements around them. Such elements as residential window units and doorways help give us an idea of how large a building is and how many stories it has. Stairs and certain modular materials, such as brick and concrete block, help us measure the scale of a space. Because of their familiarity, these elements, if oversized, can also be used to deliberately alter our perception of the size of a building form or space.

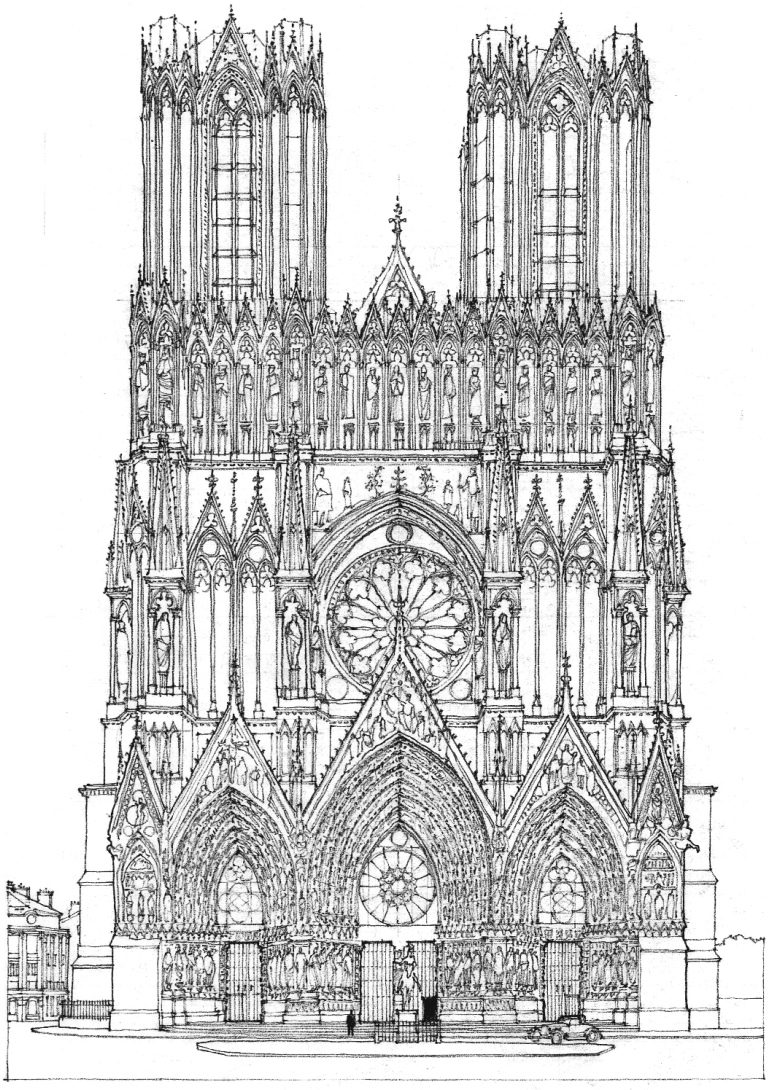


Some buildings and spaces have two or more scales operating simultaneously. The entrance portico of the library at the University of Virginia, modeled after the Pantheon in Rome, is scaled to the overall building form while the doorway and windows behind it are scaled to the size of the spaces within the building.



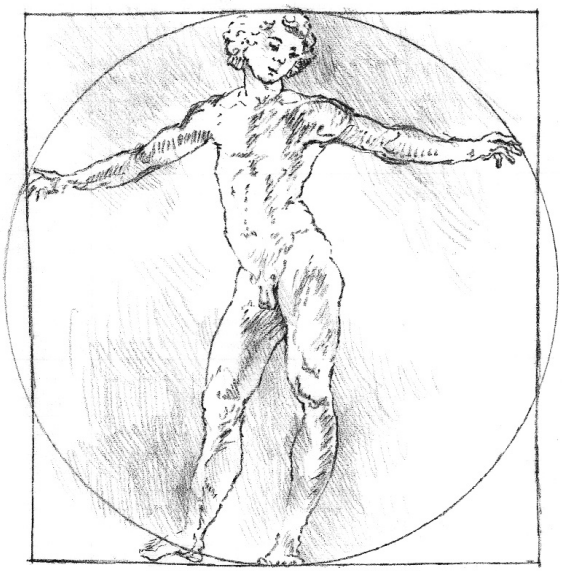
University of Virginia, Charlottesville, 1817–1826, Thomas Jefferson

The recessed entry portals of Reims Cathedral are scaled to the dimensions of the facade and can be seen and recognized at a distance as the entrances to the interior space of the church. As we get closer, however, we see that the actual entrances are really simple doors within the larger portals and are scaled to our dimensions, to a human scale.



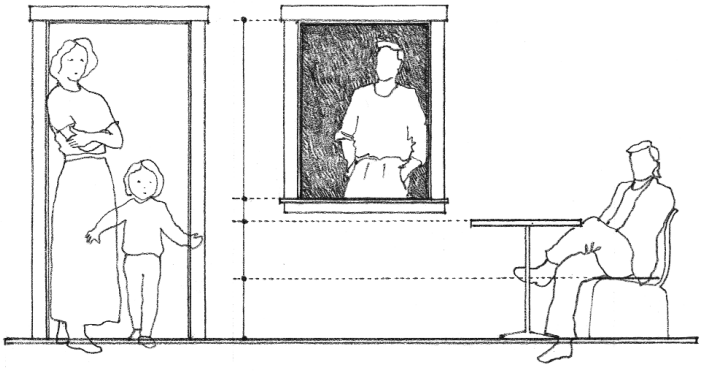
Reims Cathedral, 1211–1290

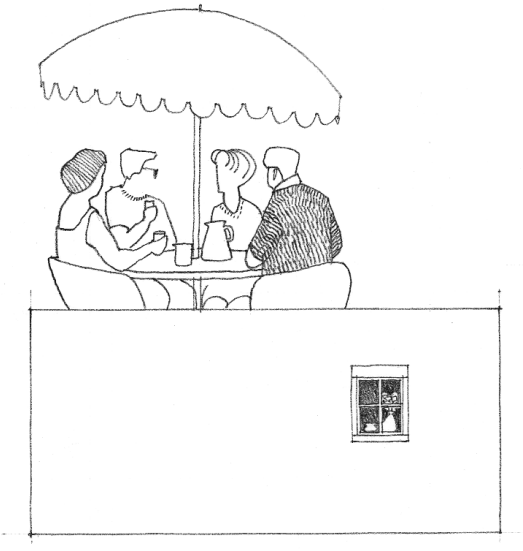
HUMAN SCALE

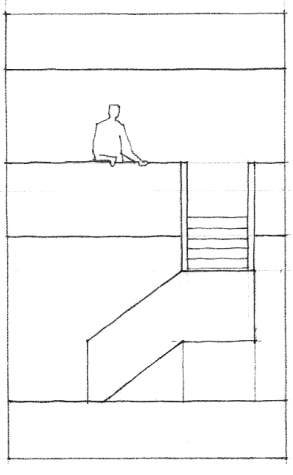


Human scale in architecture is based on the dimensions and proportions of the human body. It has already been mentioned in the section on anthropometric proportioning that our dimensions vary from individual to individual and should not be used as an absolute measuring device. We can, however, gauge a space whose width is such that we can reach out and touch its walls. Similarly, we can judge its height if we can reach up and touch the ceiling plane overhead. Once we can no longer do these things, we must rely on visual rather than tactile clues to give us a sense of the scale of a space.

For these clues, we can use elements that have human meaning and whose dimensions are related to the dimensions of our posture, pace, reach, or grasp. Such elements as a table or chair, the risers and treads of a stairway, the sill of a window, and the lintel over a doorway, not only help us judge the size of a space but also give it a human scale.







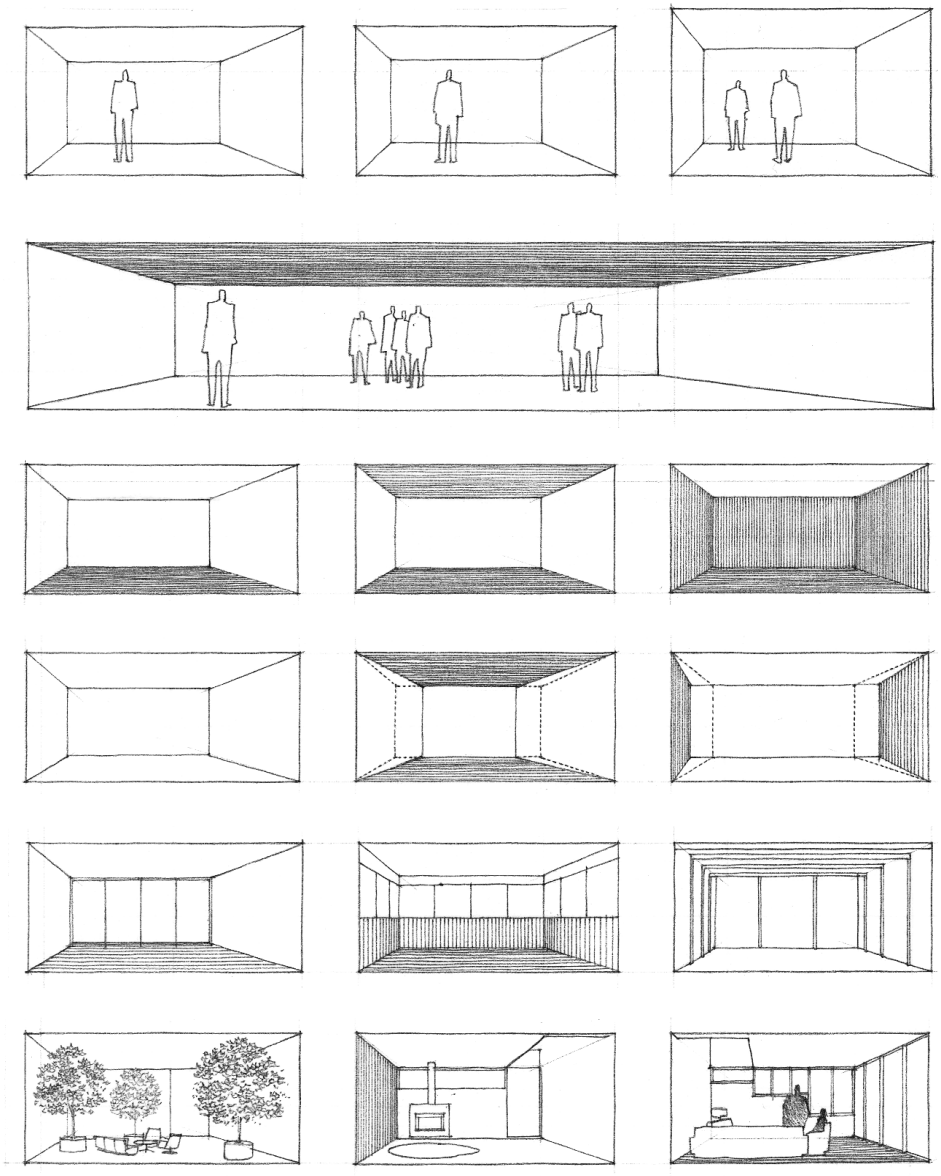
While something that is monumental in scale makes us feel small in comparison, a space that is intimate in scale describes an environment in which we feel comfortable, in control, or important. Intimate settings of tables and lounge chairs in a large hotel lobby tell us something about the expansiveness of the space as well as define comfortable, human-scale areas within it. A stairway leading up to a second-story balcony or loft can give us an idea of the vertical dimension of a room as well as suggest a human presence. A window in a blank wall conveys something about the space behind it and also leaves the impression that it is inhabited.

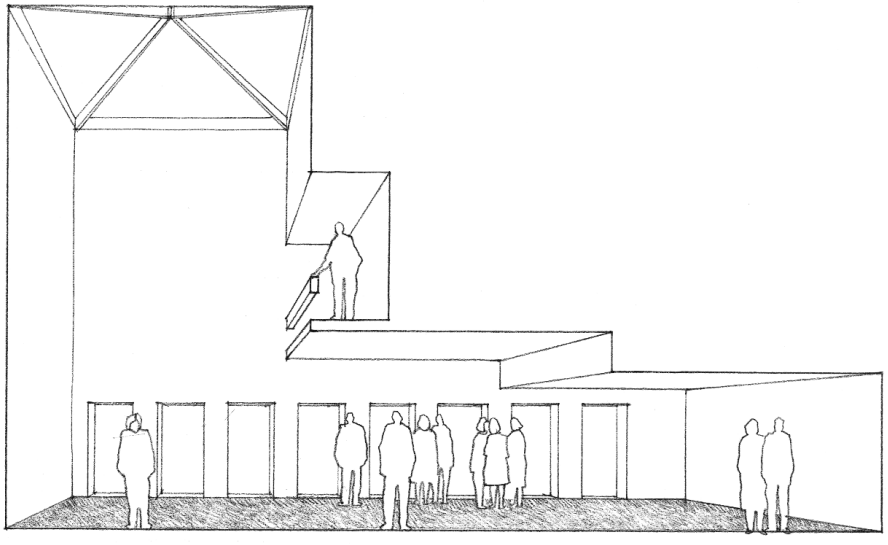
Of a room's three dimensions, its height has a greater effect on its scale than either its width or length. While the walls of the room provide enclosure, the height of the ceiling plane overhead determines its qualities of shelter and intimacy.

Raising the ceiling height of a 12 × 16-foot room from 8 to 9 feet will be more noticeable and affect its scale more than if its width were increased to 13 feet or its length to 17 feet. While the 12 × 16-foot room with a 9-foot ceiling might feel comfortable to most people, a 50 × 50-foot space with the same ceiling height would begin to feel oppressive.

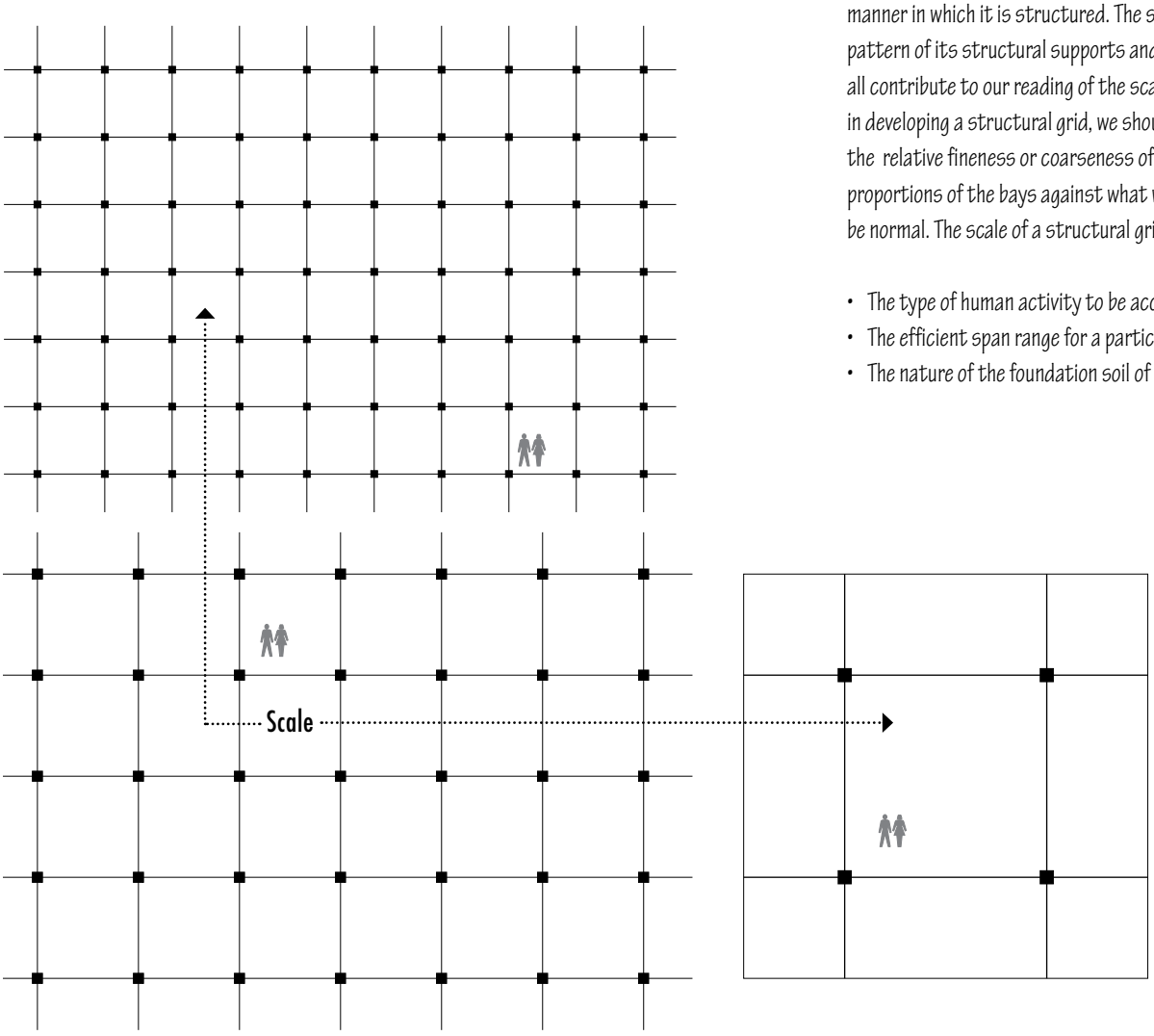
In addition to the vertical dimension of a space, other factors that affect its scale are:

- The shape, color, and pattern of its bounding surfaces
- The shape and disposition of its openings
- The nature and scale of the elements placed within it



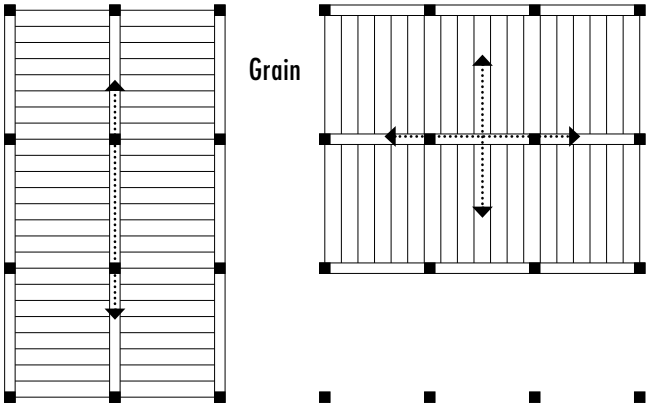


HUMAN SCALE



A major factor determining the scale of a space is the manner in which it is structured. The size, spacing, and pattern of its structural supports and spanning systems all contribute to our reading of the scale of a space. So in developing a structural grid, we should be cognizant of the relative fineness or coarseness of the dimensions and proportions of the bays against what we might consider to be normal. The scale of a structural grid is related to:

- The type of human activity to be accommodated
- The efficient span range for a particular spanning system
- The nature of the foundation soil of the building site



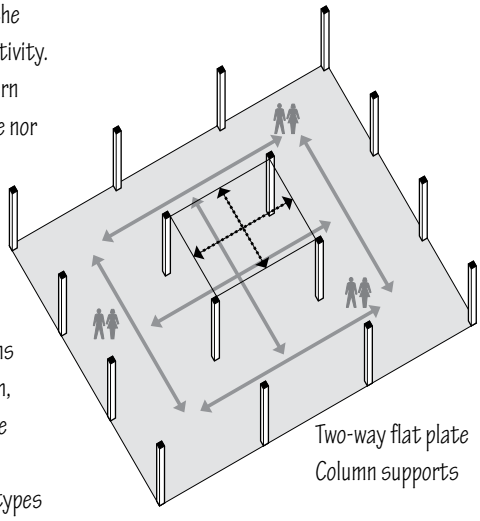
Another aspect influencing our reading of the scale of a space is the relative sizes of the members used. Some structures can be seen to be concentrated in nature due to their use of relatively large members carrying concentrated loads. On the other hand, there are some structures that use a multiplicity of small members that distribute their loads among a large number of relatively small members.

A final attribute of some structural systems is its grain, as determined by the direction, size, and arrangement of its spanning elements.

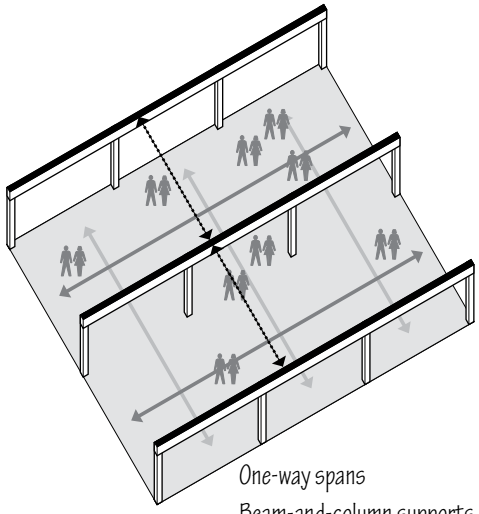
While the scale and pattern of vertical supports suggested by a structural grid influence the type of spanning system used, their arrangement should also accommodate the intended scale and patterns of human activity. At a minimum, the vertical support pattern should not limit the usefulness of a space nor constrain its intended activities.

Those activities requiring large clear spans will often dictate the structural approach, but smaller-scale activities can usually be accommodated by a variety of structural approaches. Illustrated here are various types and scales of structural patterns and the pattern and scale of human activity each might be able to accommodate.

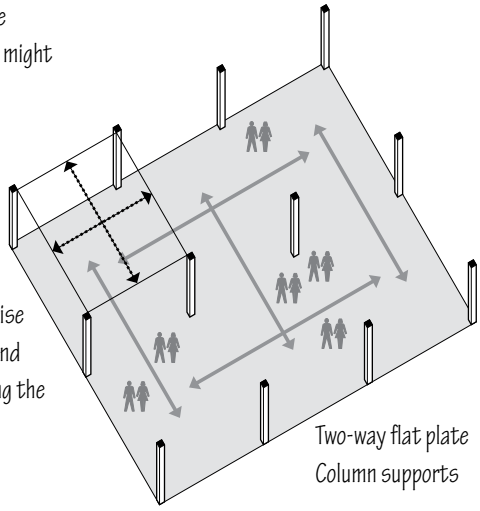
A grid of columns offers flexibility, gives rise to multiple readings of spatial volumes, and establishes a rhythm and scale for reading the spatial dimensions.



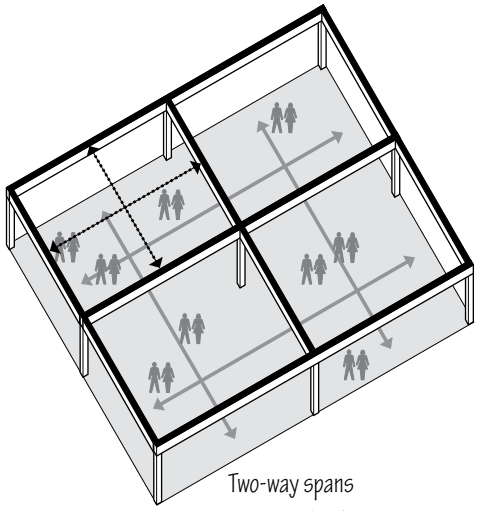
Two-way flat plate
Column supports



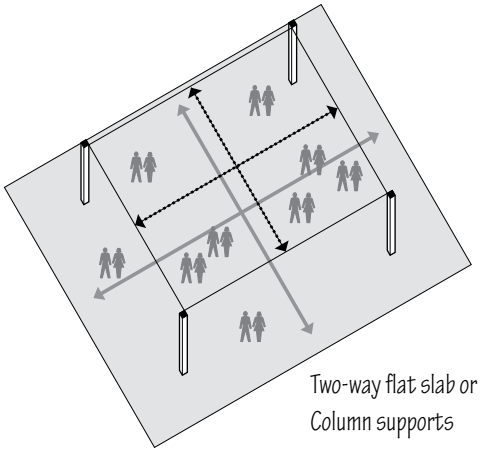
One-way spans
Beam-and-column supports



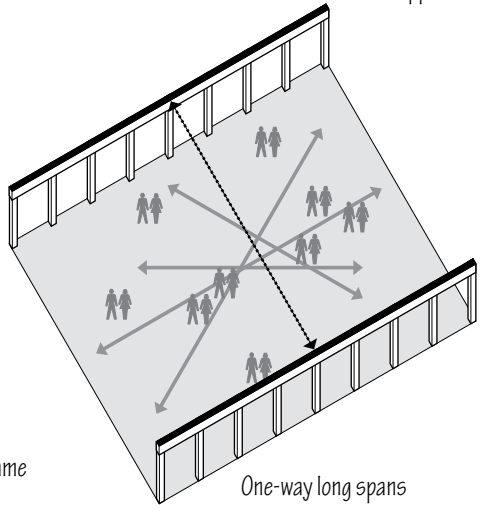
Two-way flat plate
Column supports



Two-way spans
Beam-and-column supports



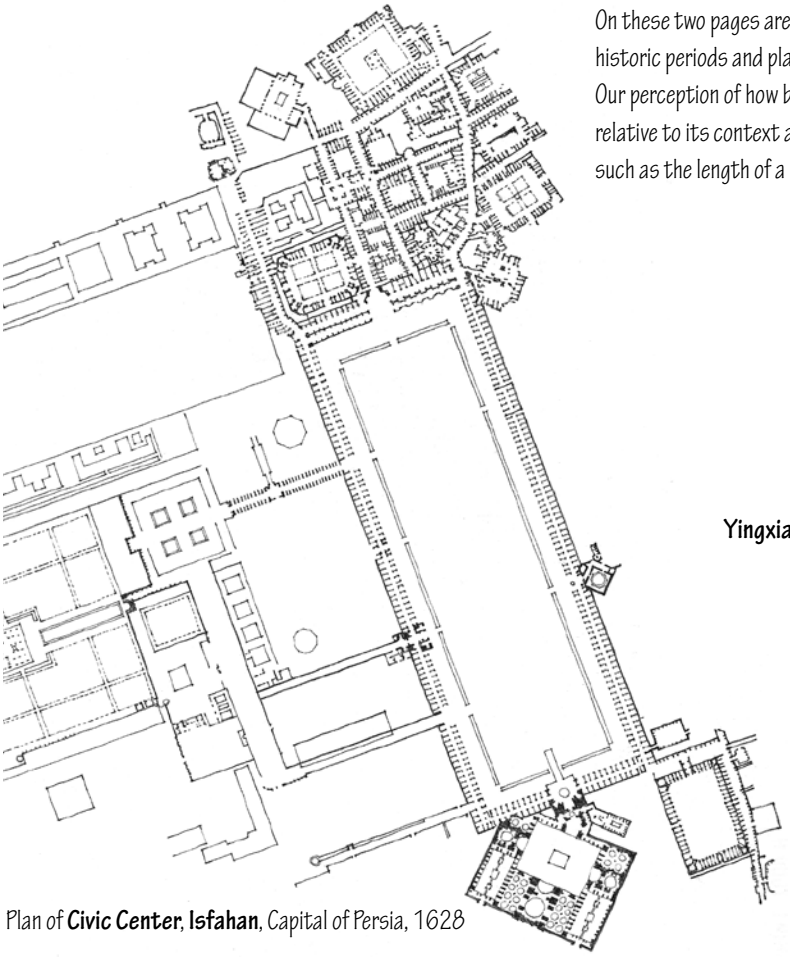
Two-way flat slab or space frame
Column supports



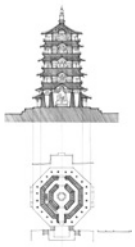
One-way long spans

A SCALAR COMPARISON

On these two pages are architectural structures from various historic periods and places drawn to the same or similar scale. Our perception of how big something or someplace is is always relative to its context and to the size of what we are familar with, such as the length of a Boeing 747 airliner.

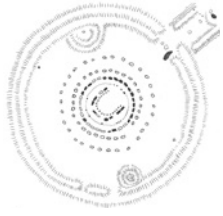


Plan of **Civic Center**, **Isfahan**, Capital of Persia, 1628



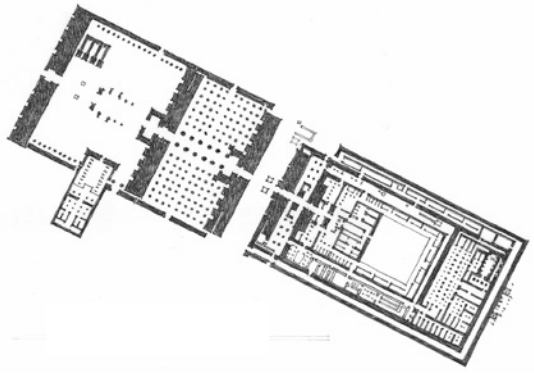
Yingxian Timber Pagoda, China, 1056

Empire State Building, New York City, 1931, Shreve, Lamb, and Harmon

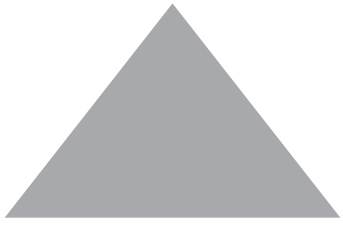


Stonehenge, c. 1800 B.C.

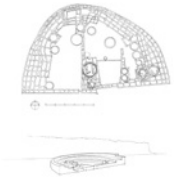
Shwezigon Pagoda, Pagan, near Nyangu, Burma, 1058



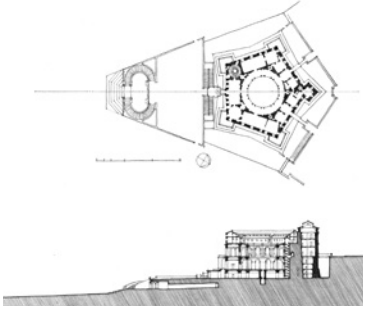
Temple of Amun at Karnak, Egypt, c. 1500–323 B.C.



Great Pyramid of Cheops at Giza, Egypt, c. 2500 B.C.

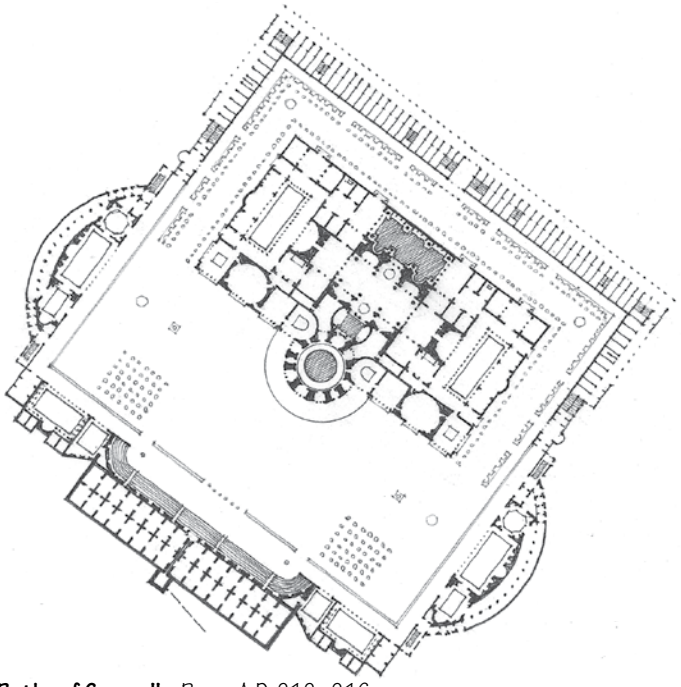


Pueblo Bonito, Chaco Canyon, USA, begun c. A.D. 920



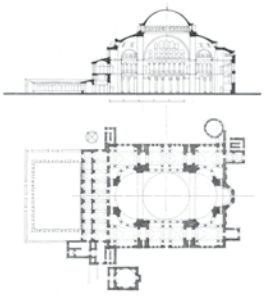
Villa Farnese, Caprarola, Italy, 1559–1560, Giacomo Vignola

A SCALAR COMPARISON



Baths of Caracalla, Rome, A.D. 212–216

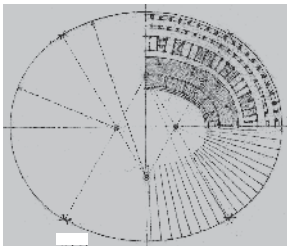
St. Peter's Basilica, 1607, Michelangelo Buonarroti and Carlo Maderno



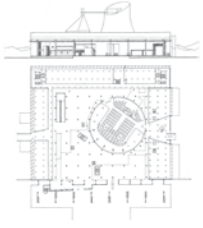
Hagia Sophia, Istanbul, Turkey, A.D. 532–537

St. Pancras Station, London, England, 1863–1876, George Gilbert Scott

Mosque of Sultan Hasan, Cairo, Egypt, 1356–1363

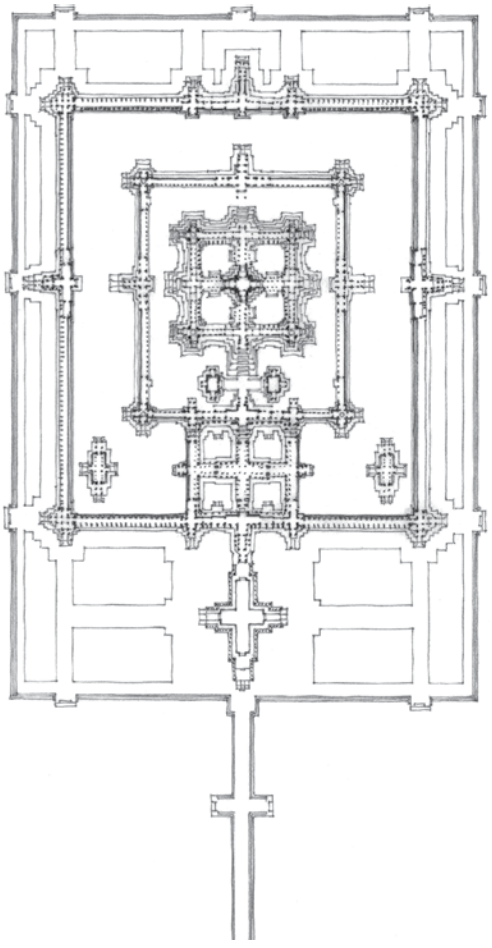


The **Colosseum**, Rome, A.D. 70–82

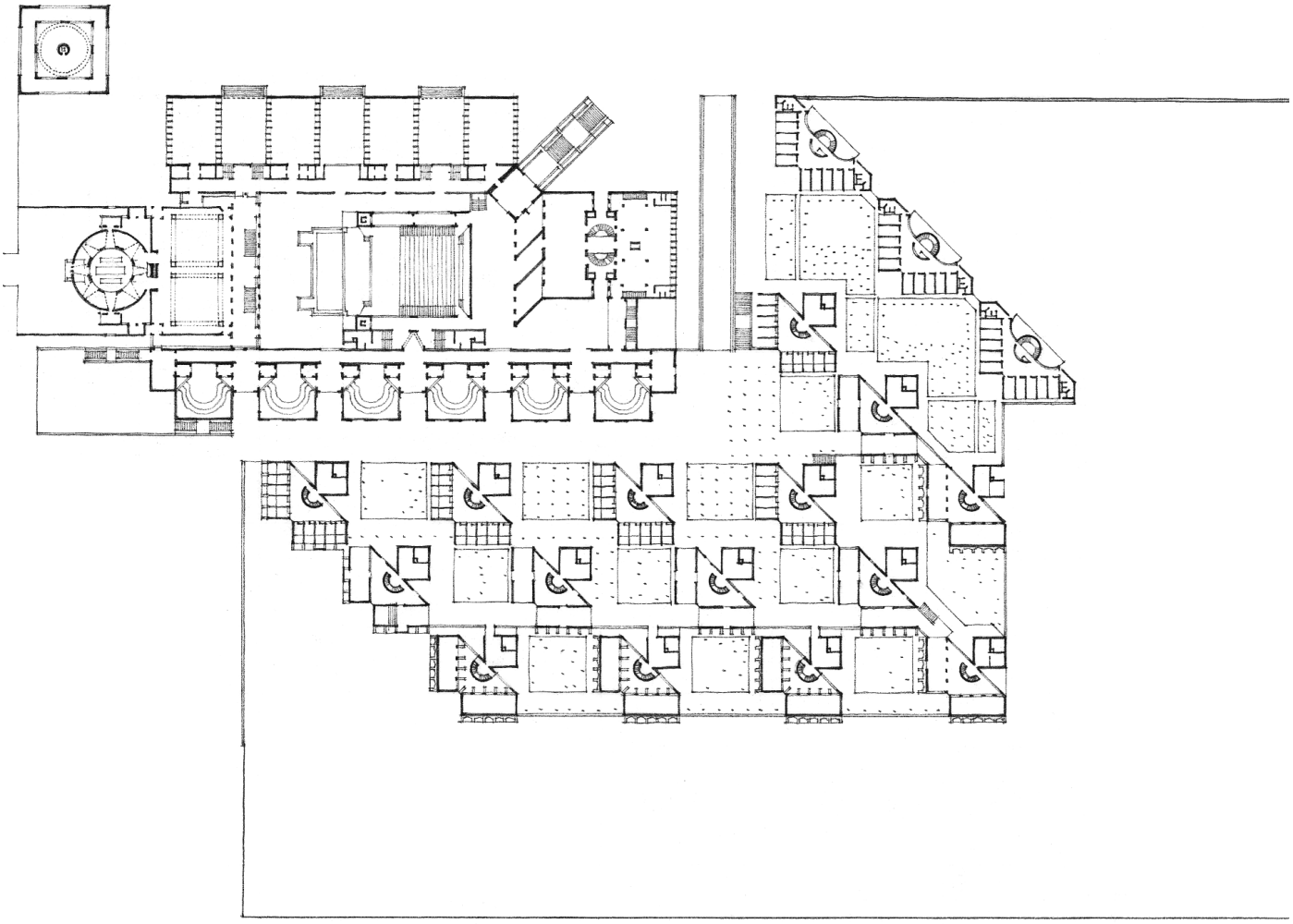


Legislative Assembly Building, Chandigarh, India, 1956–1959, Le Corbusier

Boeing 747-400



Angkor Wat, near Siem Reap, Cambodia, 802–1220



Indian Institute of Management, Ahmedabad, India, 1965, Louis Kahn

7
Principles

"...Nothing but confusion can result when order is considered a quality that can equally well be accepted or abandoned, something that can be forgone and replaced by something else. Order must be understood as indispensable to the functioning of any organized system, whether its function be physical or mental. Just as neither an engine nor an orchestra nor a sports team can perform without the integrated cooperation of all its parts, so a work of art or architecture cannot fulfill its function and transmit its message unless it presents an ordered pattern. Order is possible at any level of complexity: in statues as simple as those on Easter Island or as intricate as those by Bernini, in a farmhouse and in a Borromini church. But if there is not order, there is no way of telling what the work is trying to say."

Rudolf Arnheim
The Dynamics of Architectural Form
1977

Architecture: Form, Space, & Order, Fifth Edition. Francis D. K. Ching.
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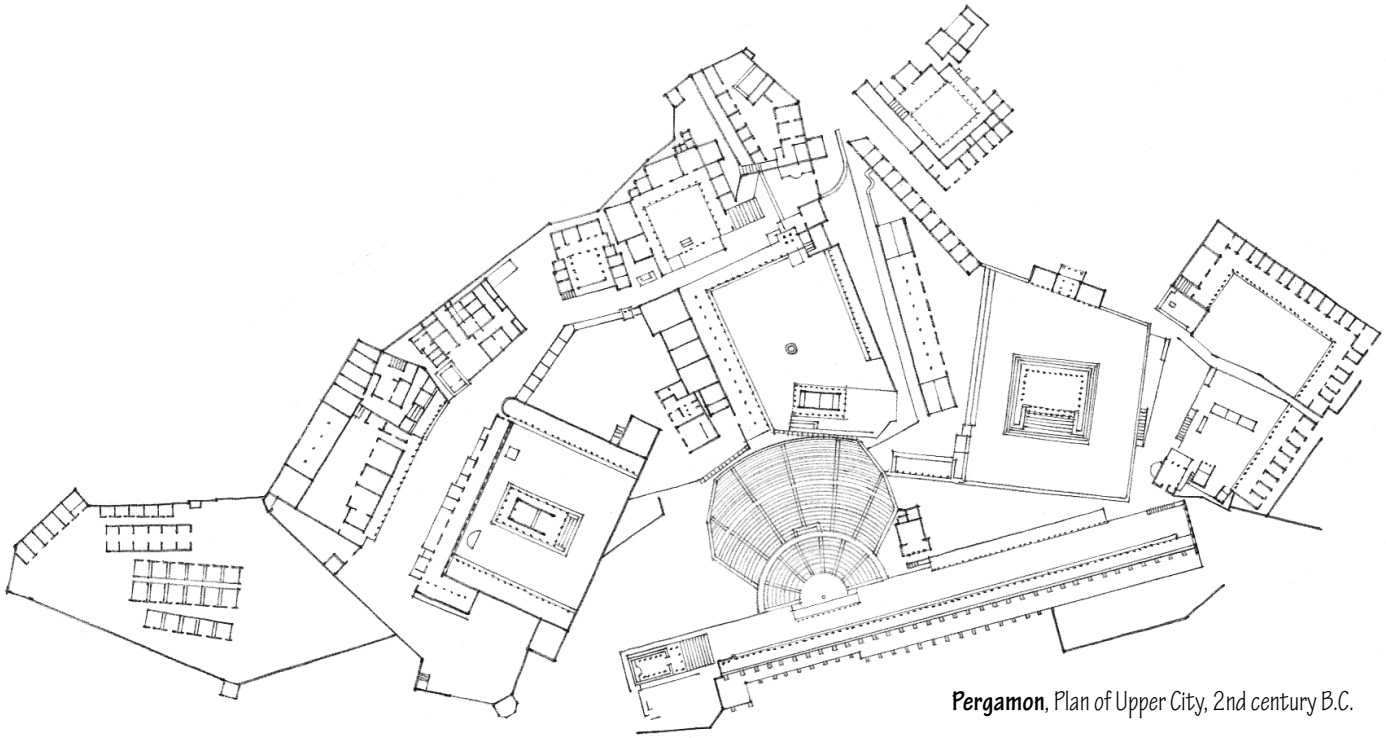
Companion Website: www.wiley.com/go/ching/architecturefso5e

ORDERING PRINCIPLES

While Chapter 4 employed a geometric basis for organizing the forms and spaces of a building, this chapter discusses additional principles that can be utilized to create order in an architectural composition. Order refers not simply to geometric regularity, but rather to a condition in which each part of a whole is properly disposed with reference to other parts and to its purpose so as to produce a harmonious arrangement.

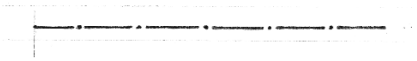
There exists a natural diversity and complexity in the program requirements for buildings. The forms and spaces of any building should acknowledge the hierarchy inherent in the functions they accommodate, the users they serve, the purposes or meaning they convey, and the scope or context they address. It is in recognition of this natural diversity, complexity, and hierarchy in the programming, designing, and making of buildings that ordering principles are discussed.

Order without diversity can result in monotony or boredom; diversity without order can produce chaos. A sense of unity with variety is the ideal. The following ordering principles are seen as visual devices that allow the varied and diverse forms and spaces of a building to coexist perceptually and conceptually within an ordered, unified, and harmonious whole.



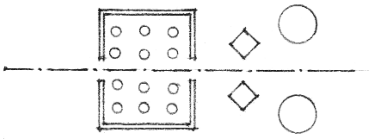
Pergamon, Plan of Upper City, 2nd century B.C.

Axis



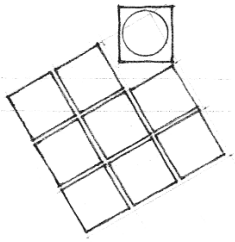
A line established by two points in space, about which forms and spaces can be arranged in a symmetrical or balanced manner

Symmetry



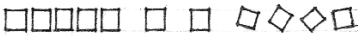
The balanced distribution and arrangement of equivalent forms and spaces on opposite sides of a dividing line or plane, or about a center or axis

Hierarchy



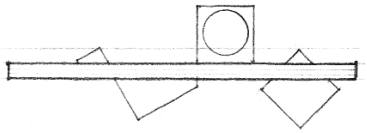
The articulation of the importance or significance of a form or space by its size, shape, or placement relative to the other forms and spaces of the organization

Rhythm



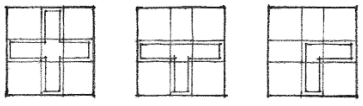
A unifying movement characterized by a patterned repetition or alternation of formal elements or motifs in the same or a modified form

Datum



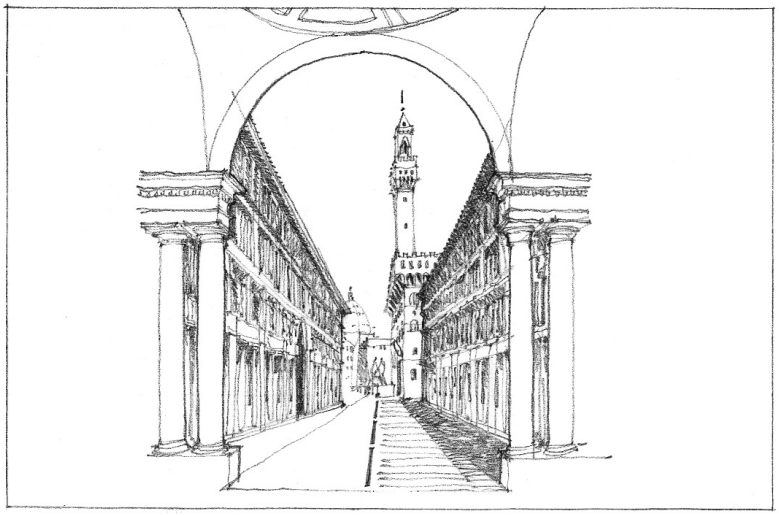
A line, plane, or volume that, by its continuity and regularity, serves to gather, measure, and organize a pattern of forms and spaces

Transformation



The principle that an architectural concept, structure, or organization can be altered through a series of discrete manipulations and permutations in response to a specific context or set of conditions without a loss of identity or concept

AXIS

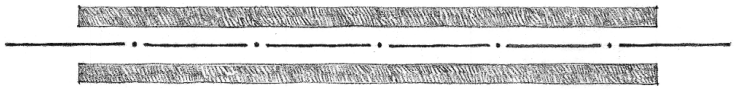


This Florentine street flanked by the **Uffizi Palace** links the River Arno to the Piazza della Signoria. See plan on pg. 386.

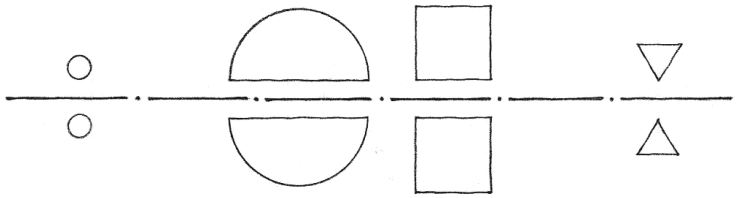
The axis is perhaps the most elementary means of organizing forms and spaces in architecture. It is a line established by two points in space, about which forms and spaces can be arranged in a regular or irregular manner. Although imaginary and not visible except to the mind's eye, an axis can be a powerful, dominating, regulating device. It implies symmetry; it demands balance. The specific disposition of elements about an axis will determine whether the visual force of an axial organization is subtle or overpowering, loosely structured or formal, picturesque or monotonous.

Since an axis is essentially a linear condition, it has qualities of length and direction, and induces movement and promotes views along its path.

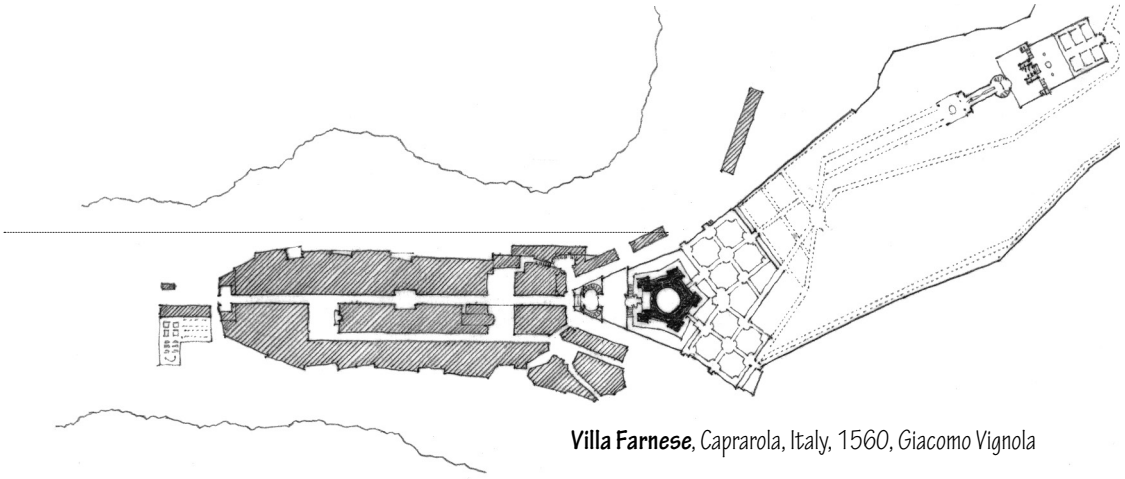
For its definition, an axis must be terminated at both of its ends by a significant form or space.



The notion of an axis can be reinforced by defining edges along its length. These edges can be simply lines on the ground plane, or vertical planes that define a linear space coincident with the axis.



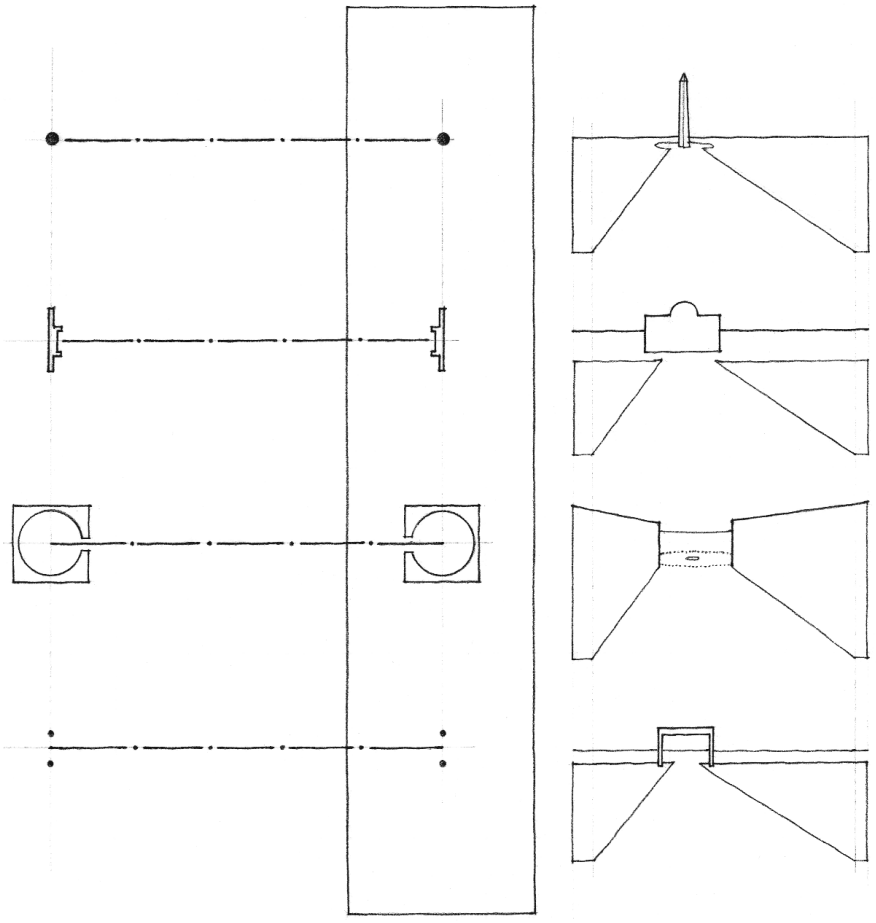
An axis can also be established simply by a symmetrical arrangement of forms and spaces.



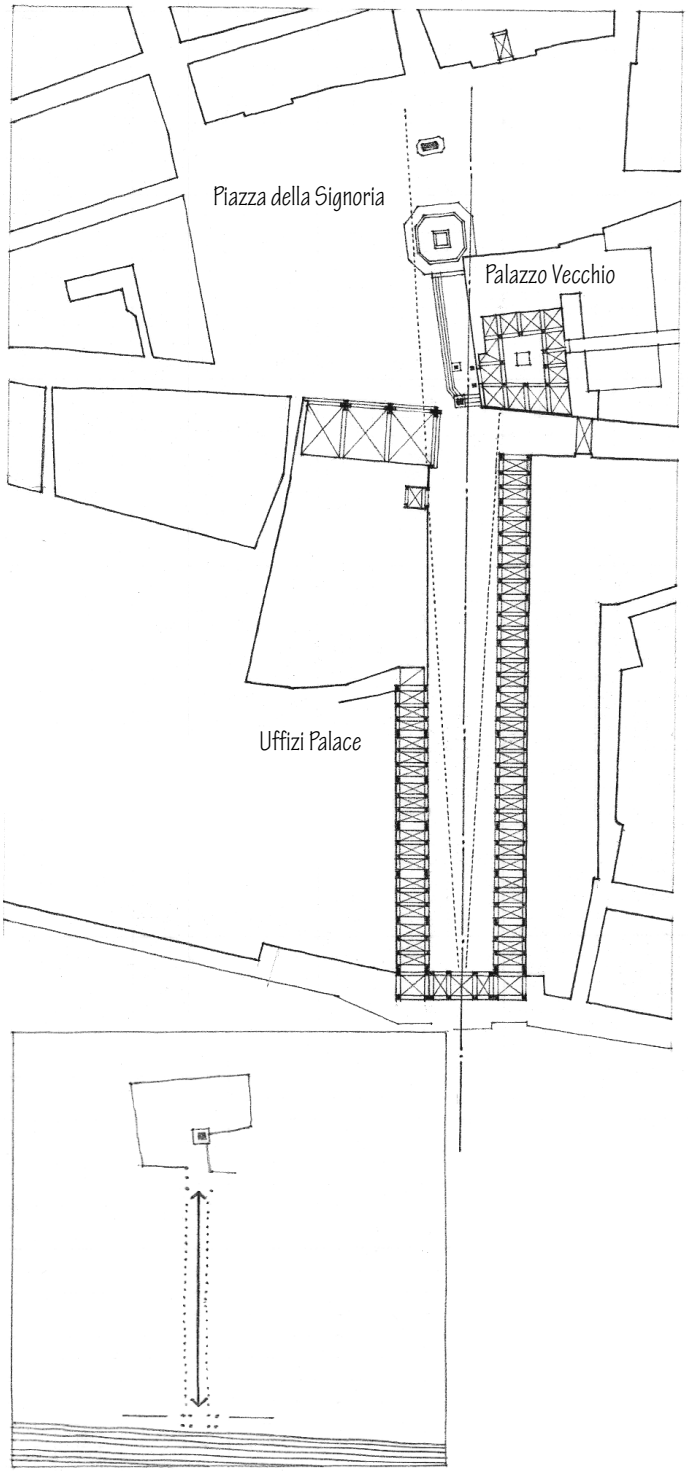
Villa Farnese, Caprarola, Italy, 1560, Giacomo Vignola

The terminating elements of an axis serve to both send and receive its visual thrust. These culminating elements can be any of the following:

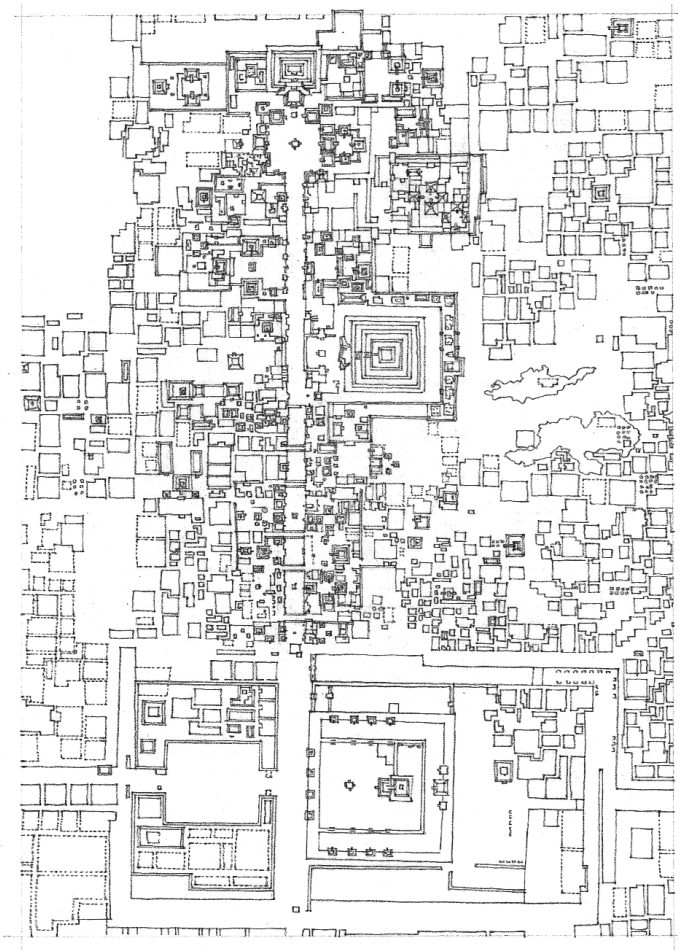
- Points in space established by vertical, linear elements or centralized building forms
- Vertical planes, such as symmetrical building facades or fronts, preceded by a forecourt or similar open space
- Well-defined spaces, generally centralized or regular in form
- Gateways that open outward toward a view or vista beyond

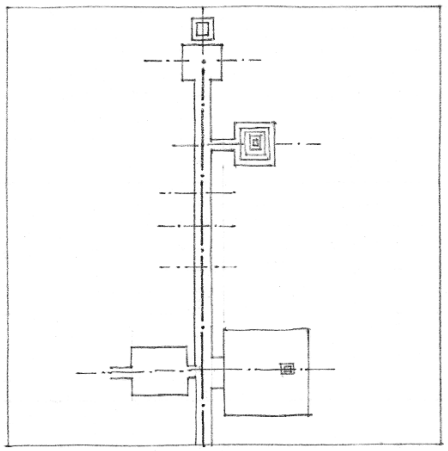


AXIS

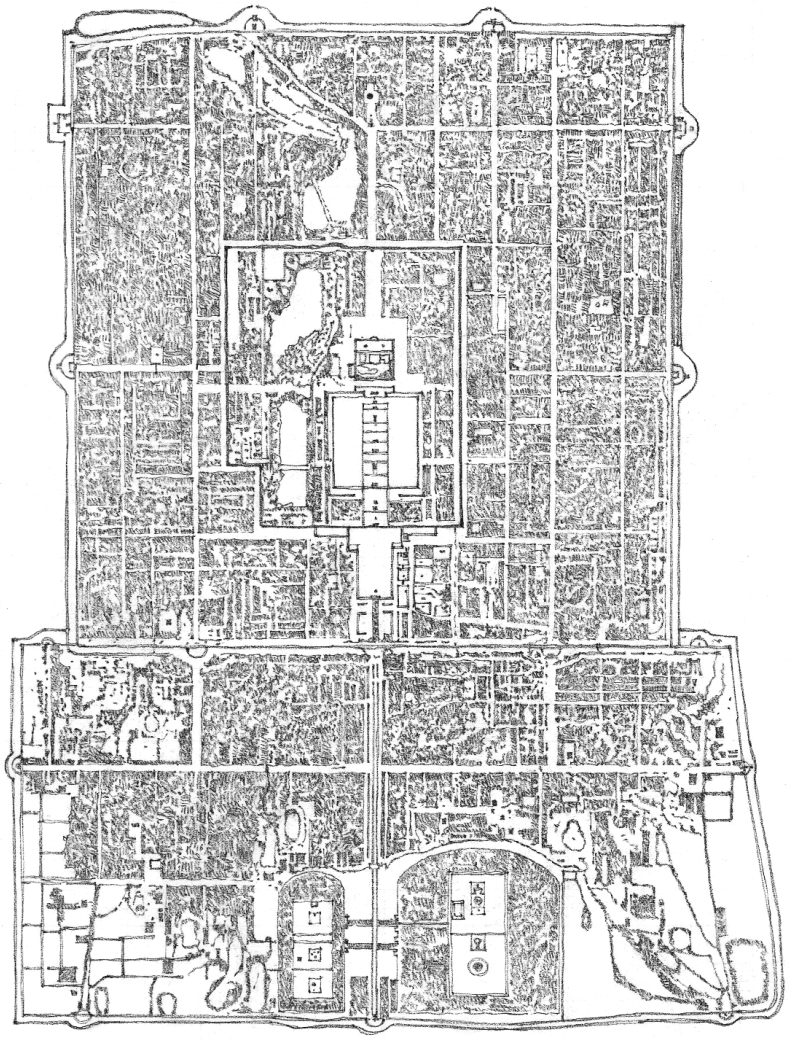


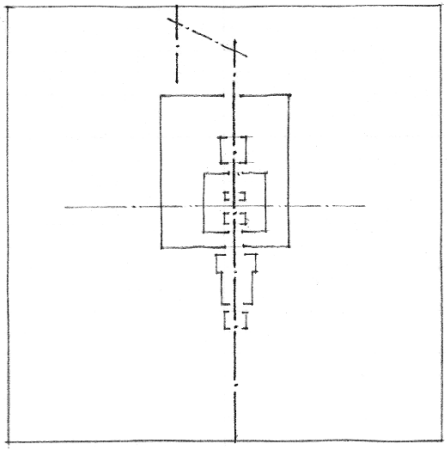
The wings of the **Uffizi Palace** in Florence, Italy (1560, Giorgio Vasari) frame an axial space that leads from the River Arno, through the Uffizi arch, to the **Piazza della Signoria** and the **Palazzo Vecchio** (1298–1314, Arnolfo di Cambio).





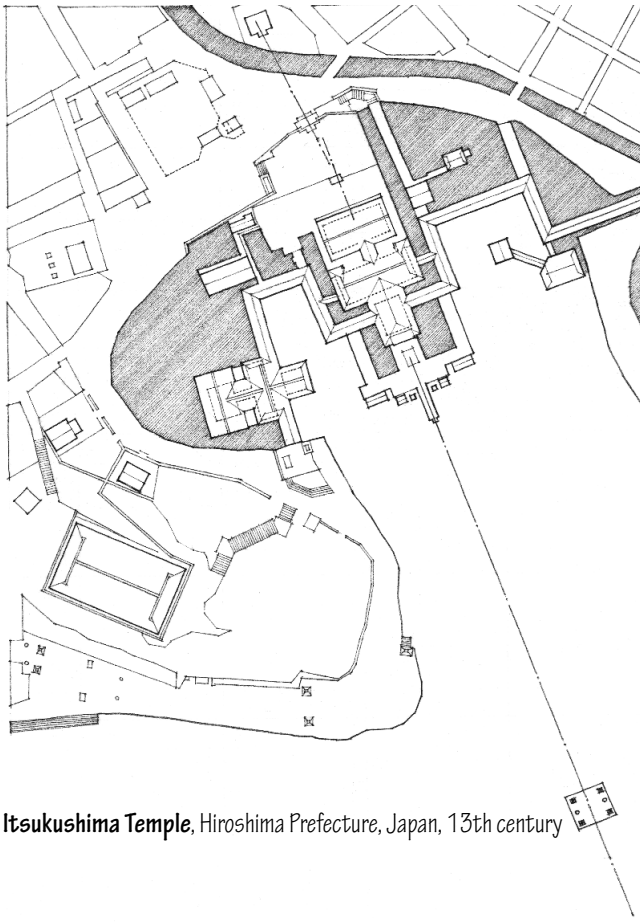
Teotihuacan, City of the Gods. Located near Mexico City, Teotihuacan was the largest and most influential ritual center of Mesoamerica, founded c. 100 B.C. and flourishing until about A.D. 750. The site was dominated by two massive temple-pyramids, the Pyramid of the Sun and the smaller Pyramid of the Moon, from which the Avenue of the Dead runs south to the citadel and market compound in the center of the city.



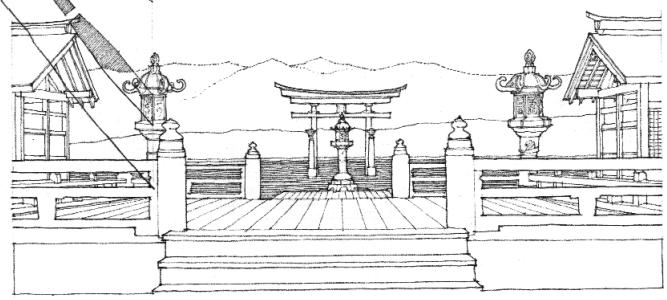


Plan of **Beijing** (formerly Peking), China. Located on its north-south axis is the **Forbidden City**, a walled section within the inner city, built in the 15th century and containing the Imperial Palace and other buildings of the imperial government of China. It was so named because it was formerly closed to the public.

AXIS

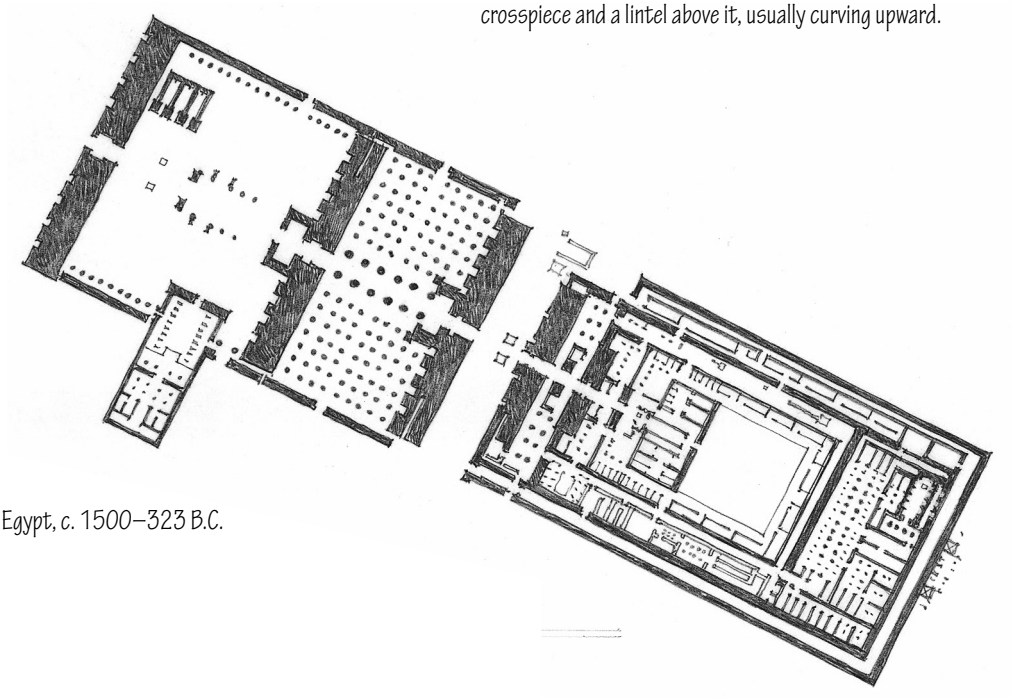


Itsukushima Temple, Hiroshima Prefecture, Japan, 13th century

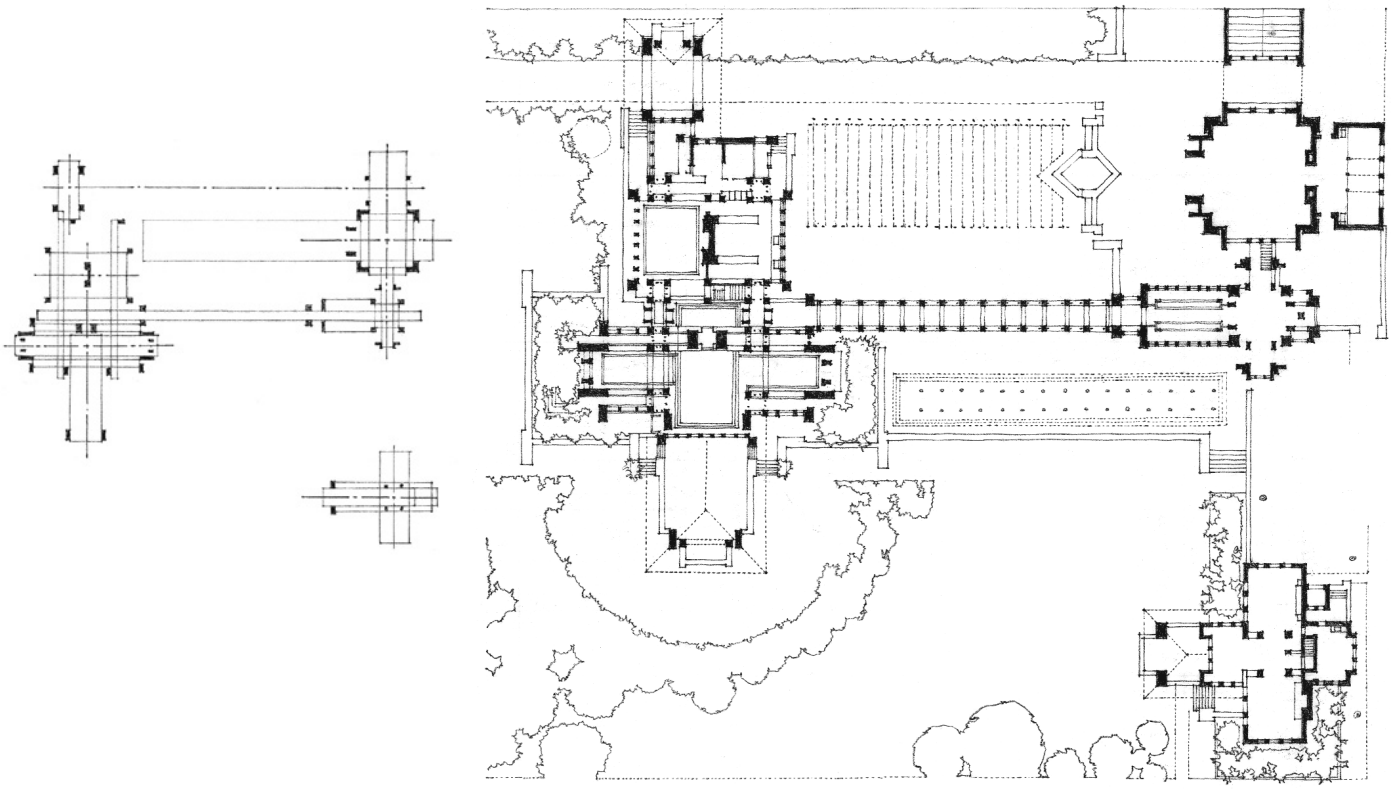


View from the Temple toward the Torii, a symbolic gateway in the sea.

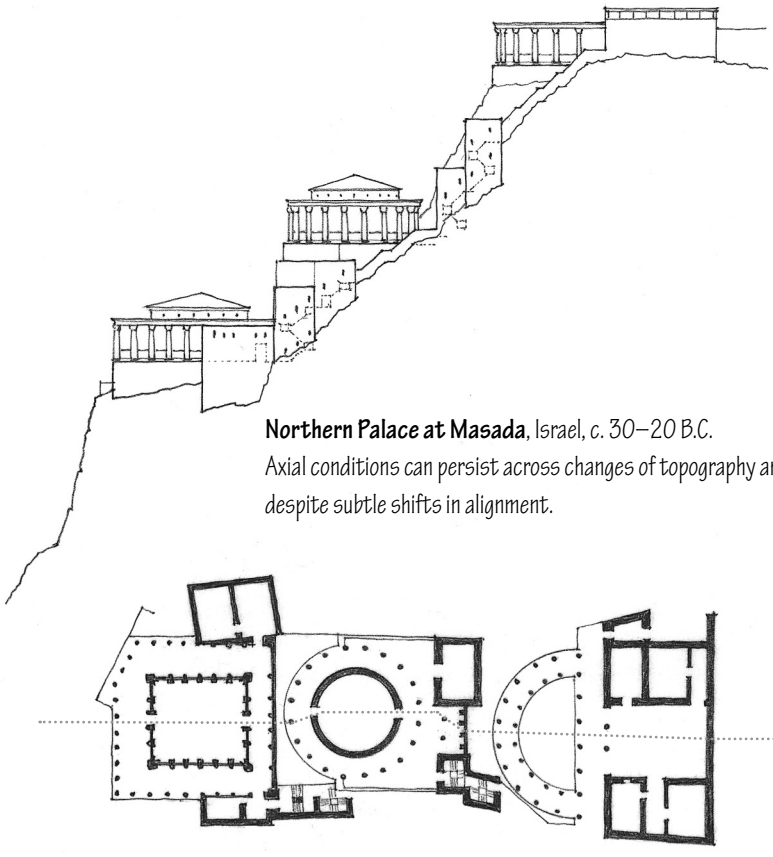
Torii is a monumental, freestanding gateway on the approach to a Shinto shrine, consisting of two pillars connected at the top by a horizontal crosspiece and a lintel above it, usually curving upward.



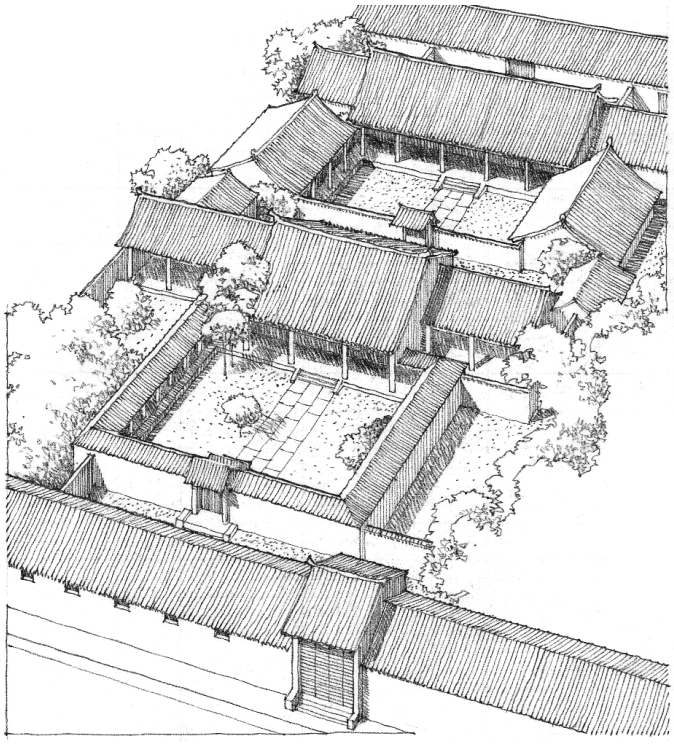
Temple of Amun at Karnak, Egypt, c. 1500–323 B.C.

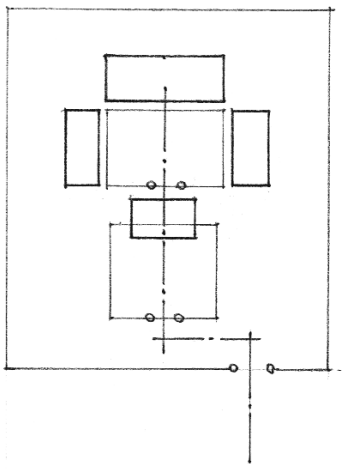


Darwin D. Martin House and Estate, Buffalo, New York, 1904, Frank Lloyd Wright

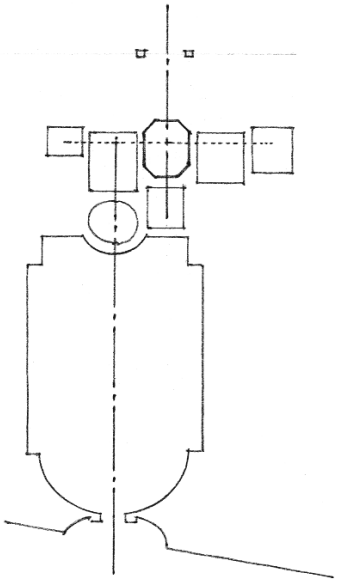


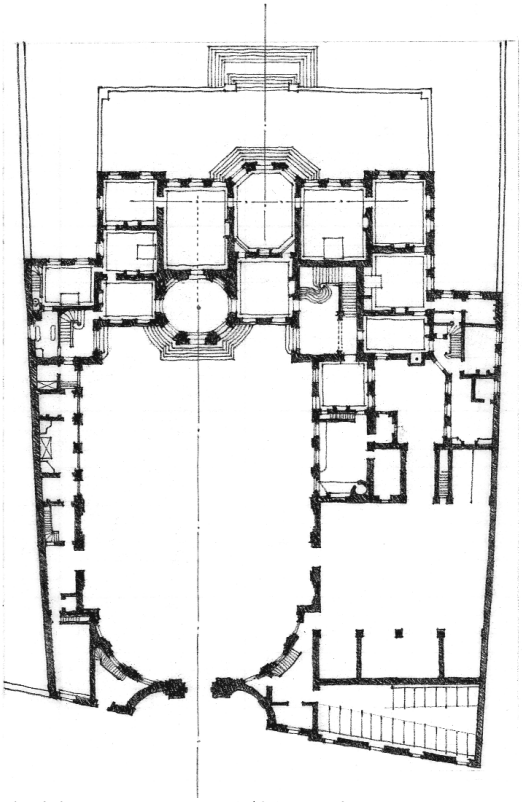
Northern Palace at Masada, Israel, c. 30–20 B.C.
Axial conditions can persist across changes of topography and despite subtle shifts in alignment.



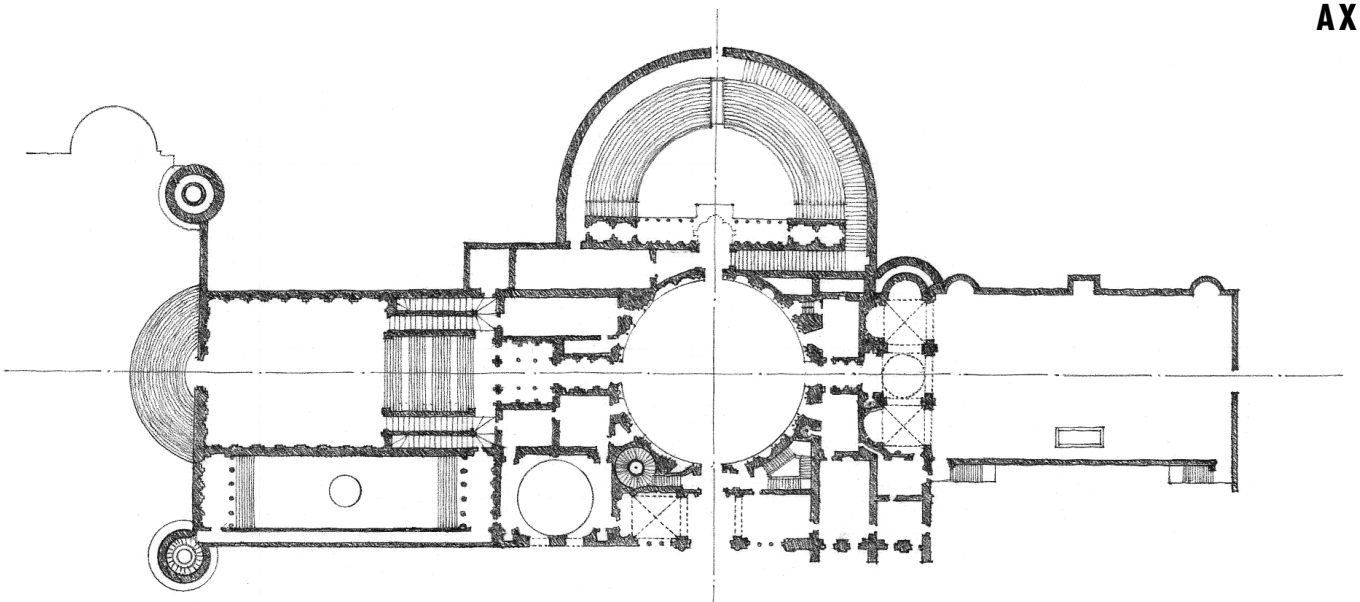


Chinese Courtyard House, Beijing, China

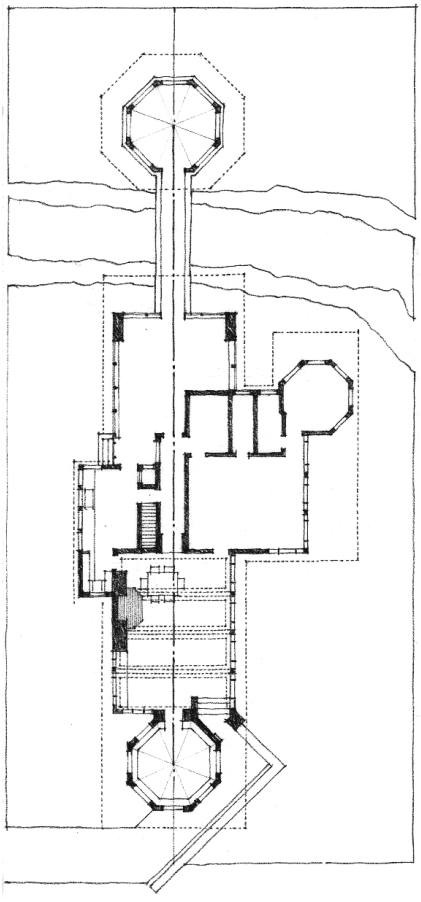




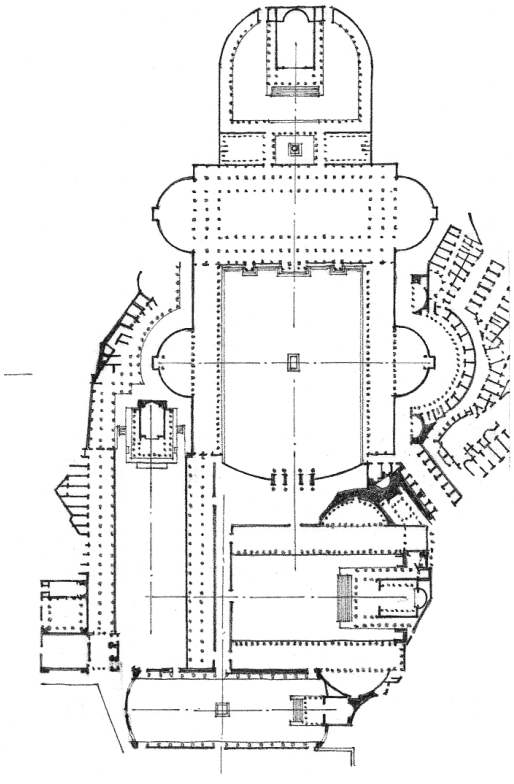
Hôtel de Matignon, Paris, 1721, Jean Courtonne



Villa Madama, Rome, 1517, Raphael Sanzio

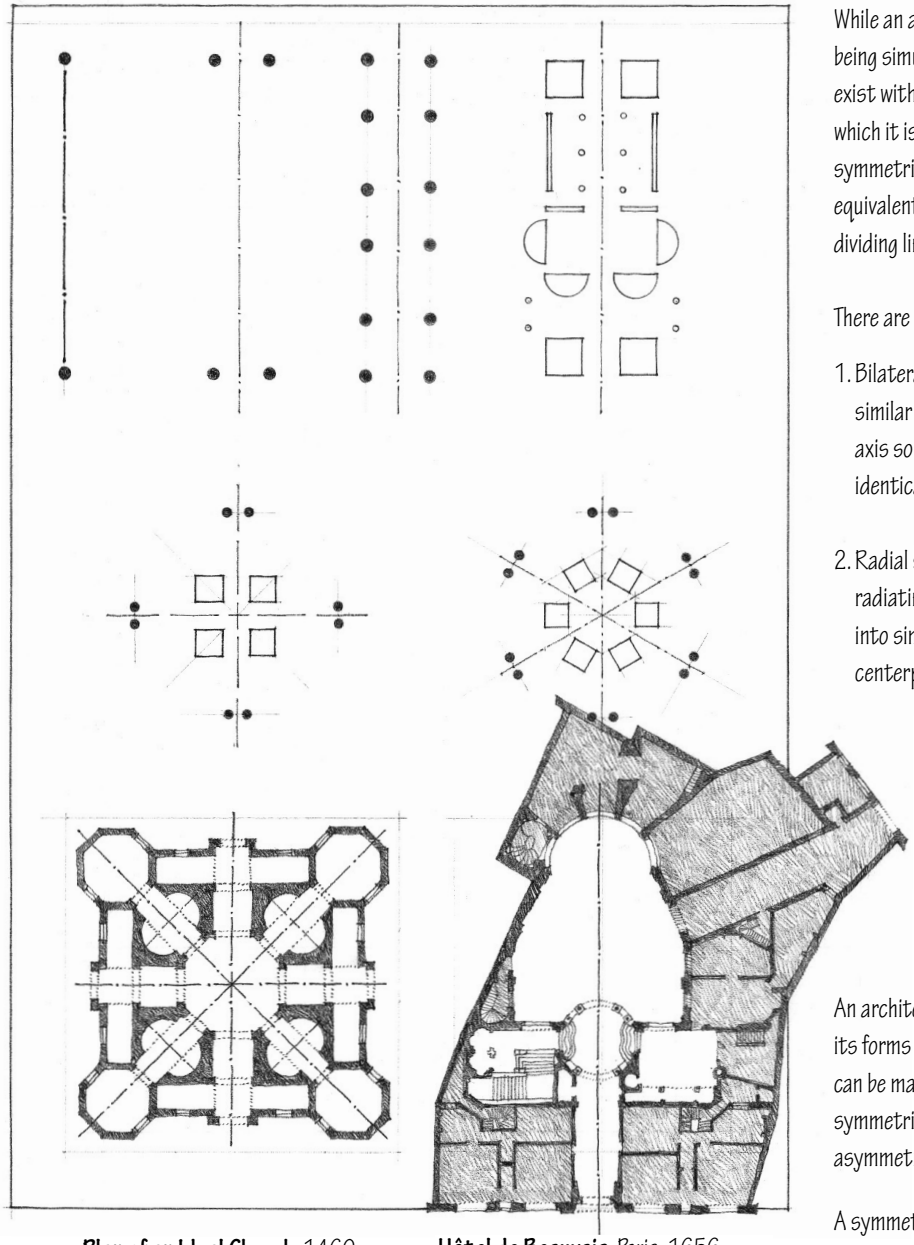


W.A. Glasner House, Glencoe, Illinois, 1905, Frank Lloyd Wright



Imperial Forums of Trajan, Augustus, Caesar, and Nerva, Rome, 1st century B.C. to 2nd century A.D.

SYMMETRY



Plan of an Ideal Church, 1460, Antonio Filarete

Hôtel de Beauvais, Paris, 1656, Antoine Le Pautre

While an axial condition can exist without a symmetrical condition being simultaneously present, a symmetrical condition cannot exist without implying the existence of an axis or center about which it is structured. An axis is established by two points; a symmetrical condition requires the balanced arrangement of equivalent patterns of form and space on opposite sides of a dividing line or plane, or about a center or axis.

There are two fundamental types of symmetry:

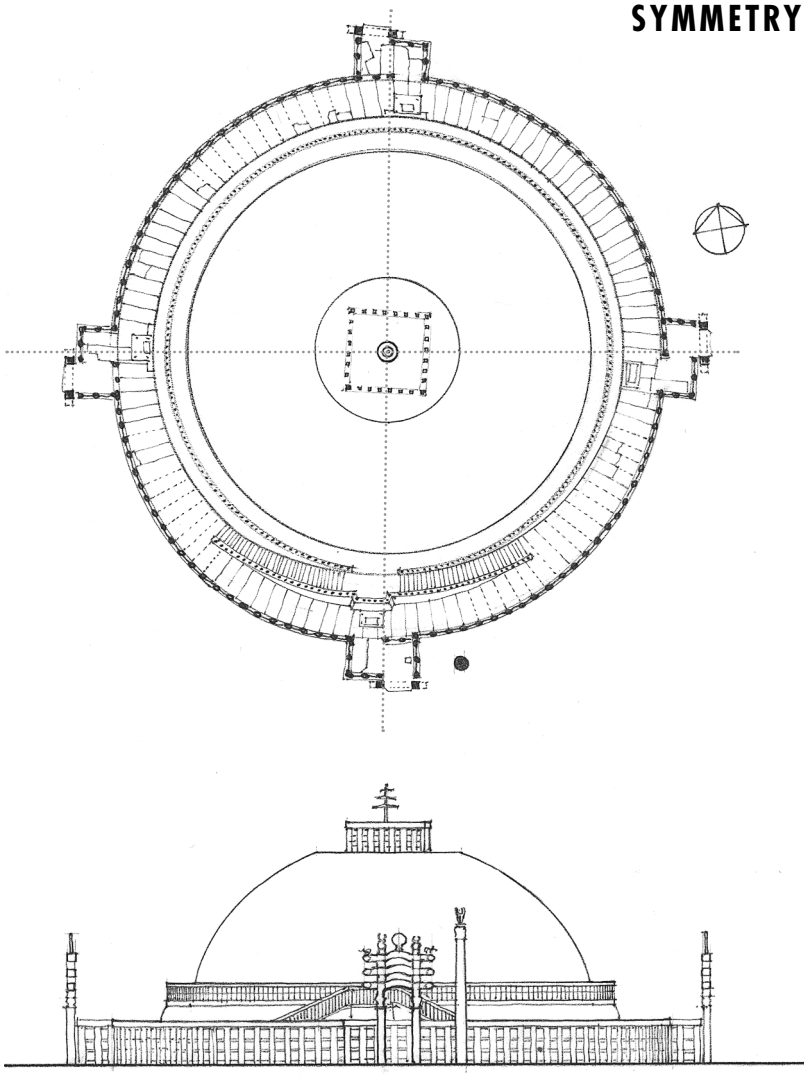
1. Bilateral symmetry refers to the balanced arrangement of similar or equivalent elements on opposite sides of a median axis so that only one plane can divide the whole into essentially identical halves.

2. Radial symmetry refers to the balanced arrangement of similar, radiating elements such that the composition can be divided into similar halves by passing a plane at any angle around a centerpoint or along a central axis.

An architectural composition can utilize symmetry to organize its forms and spaces in two ways. An entire building organization can be made symmetrical. At some point, however, any totally symmetrical arrangement must confront and resolve the asymmetry of its site or context.

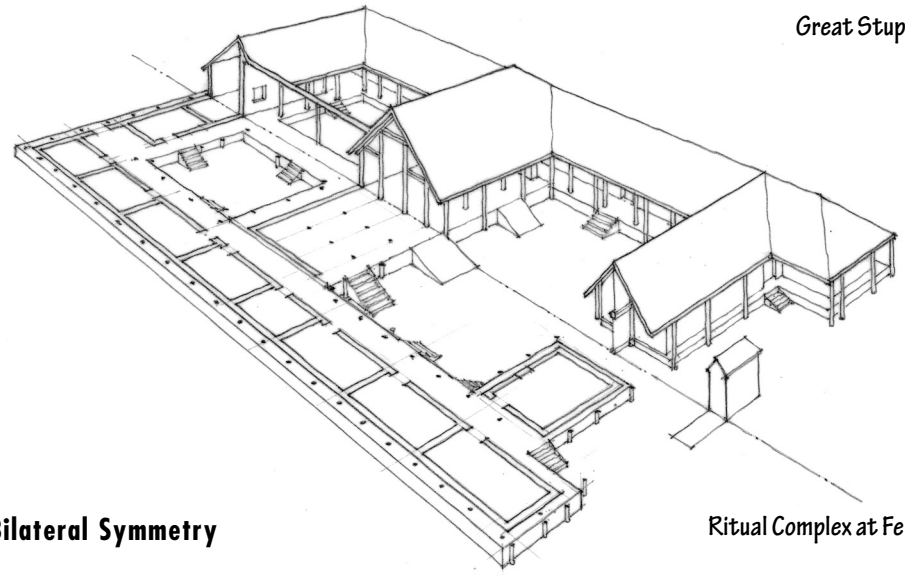
A symmetrical condition can occur in only a portion of the building and organize an irregular pattern of forms and spaces about itself. The latter case of local symmetry allows a building to respond to exceptional conditions of its site or program. The symmetrical condition itself can be reserved for significant or important spaces within the organization.

Radial Symmetry

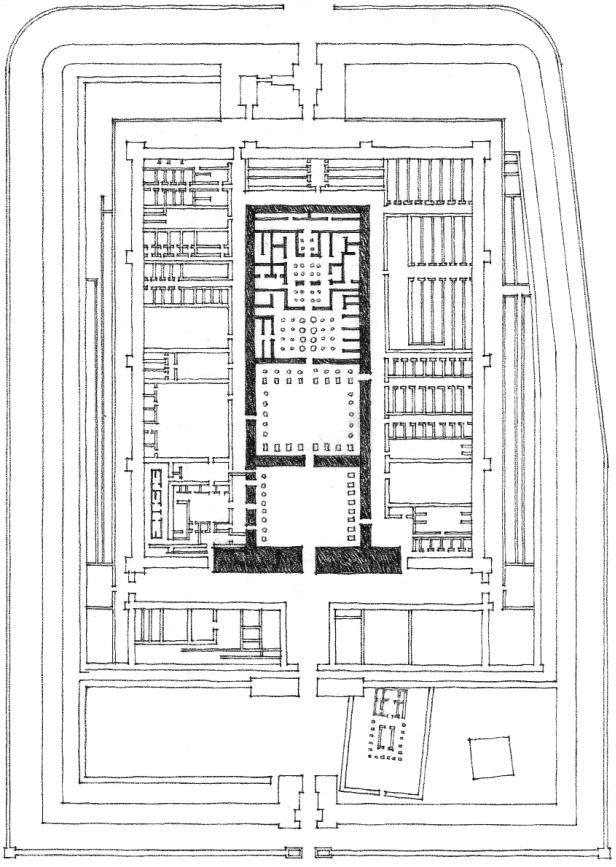


Great Stupa at Sanchi, India, *c.* 100 B.C.

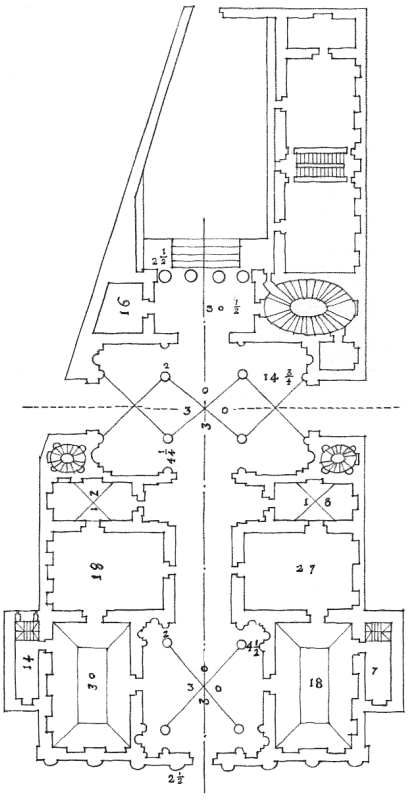
Bilateral Symmetry



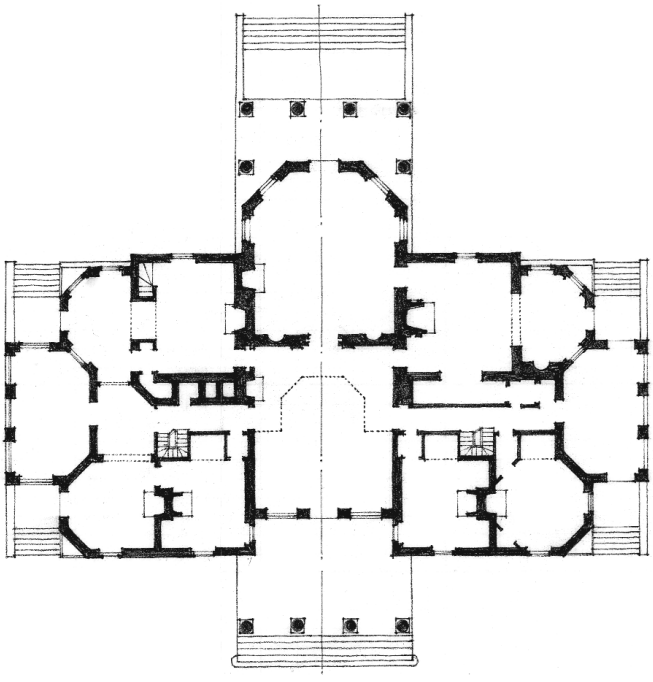
Ritual Complex at Fengchu, Shaanxi Province, China, *c.* 1100–1000 B.C.



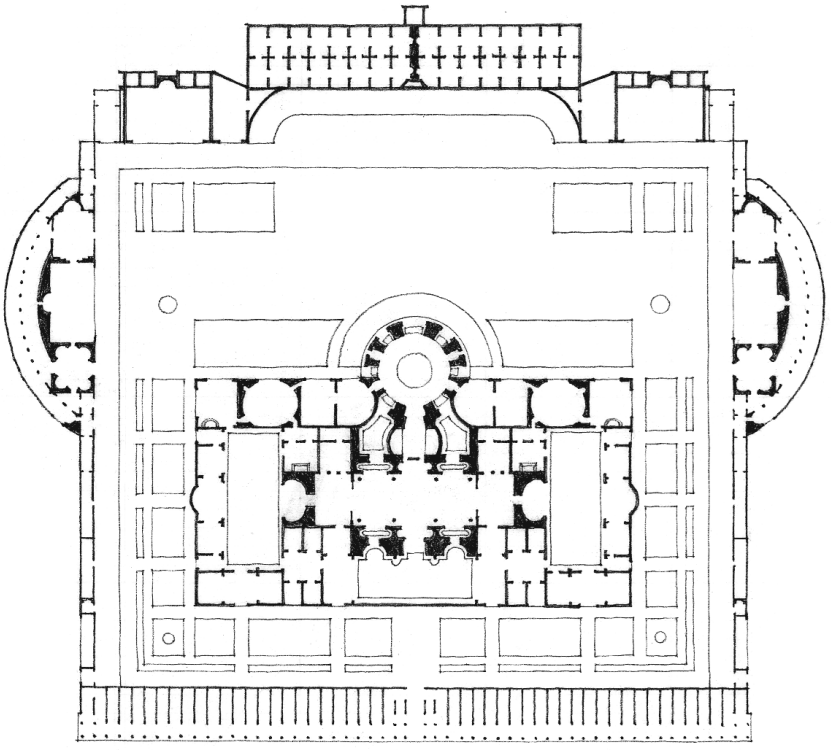
Mortuary Temple of Rameses III, Medînet-Habu, 1198 B.C.



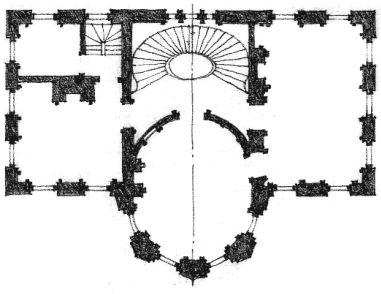
Palazzo No. 52, Andrea Palladio



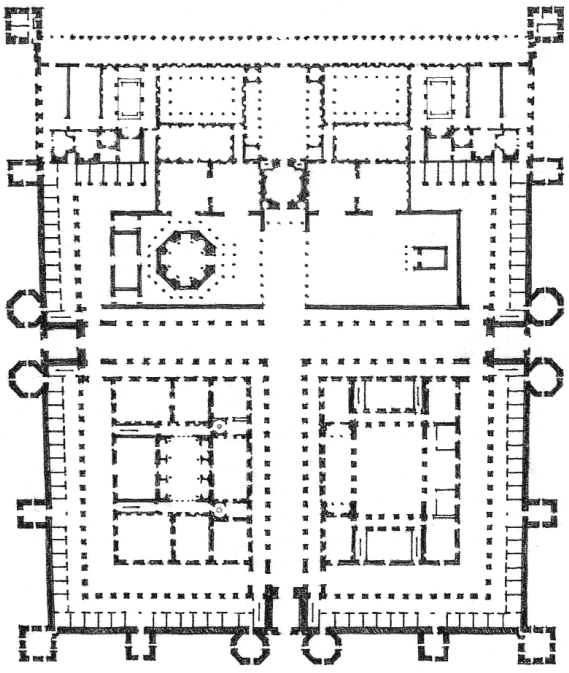
Monticello, near Charlottesville, Virginia, 1770–1808, Thomas Jefferson



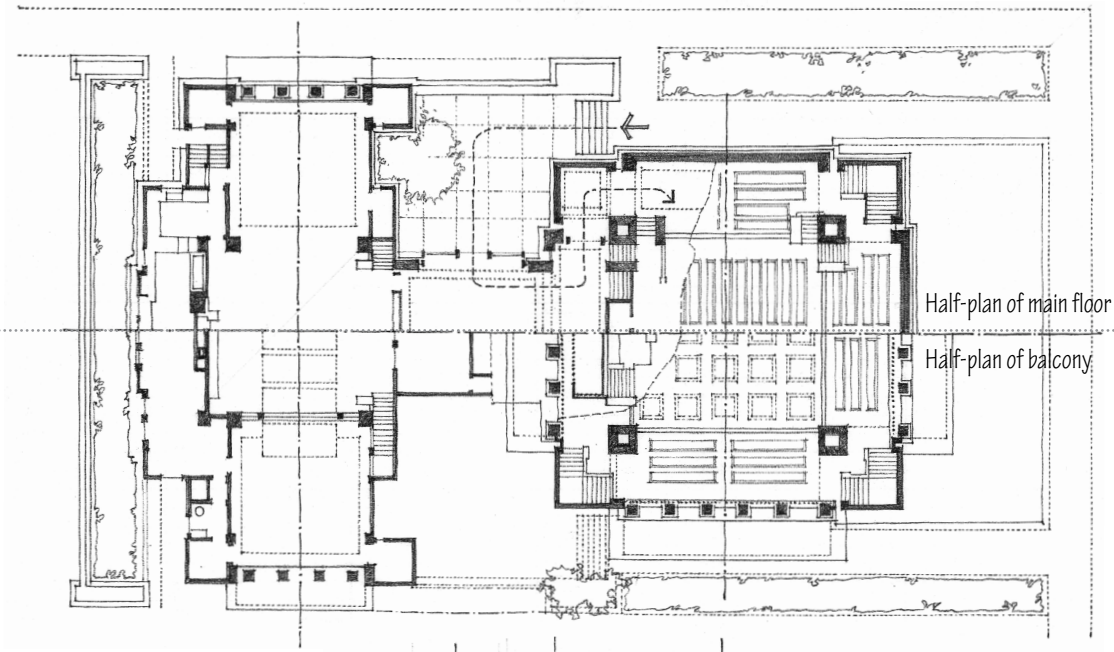
Baths of Caracalla, Rome, A.D. 211–217



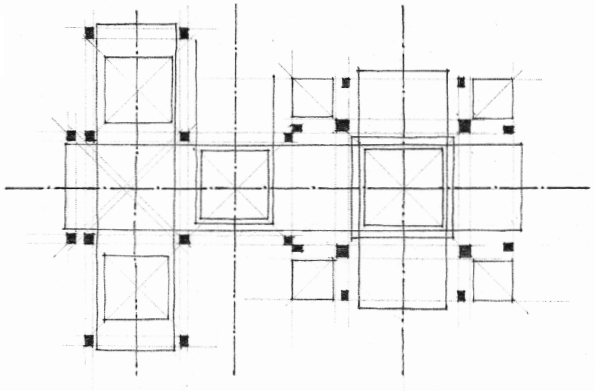
Nathaniel Russell House, Charleston, South Carolina, 1809



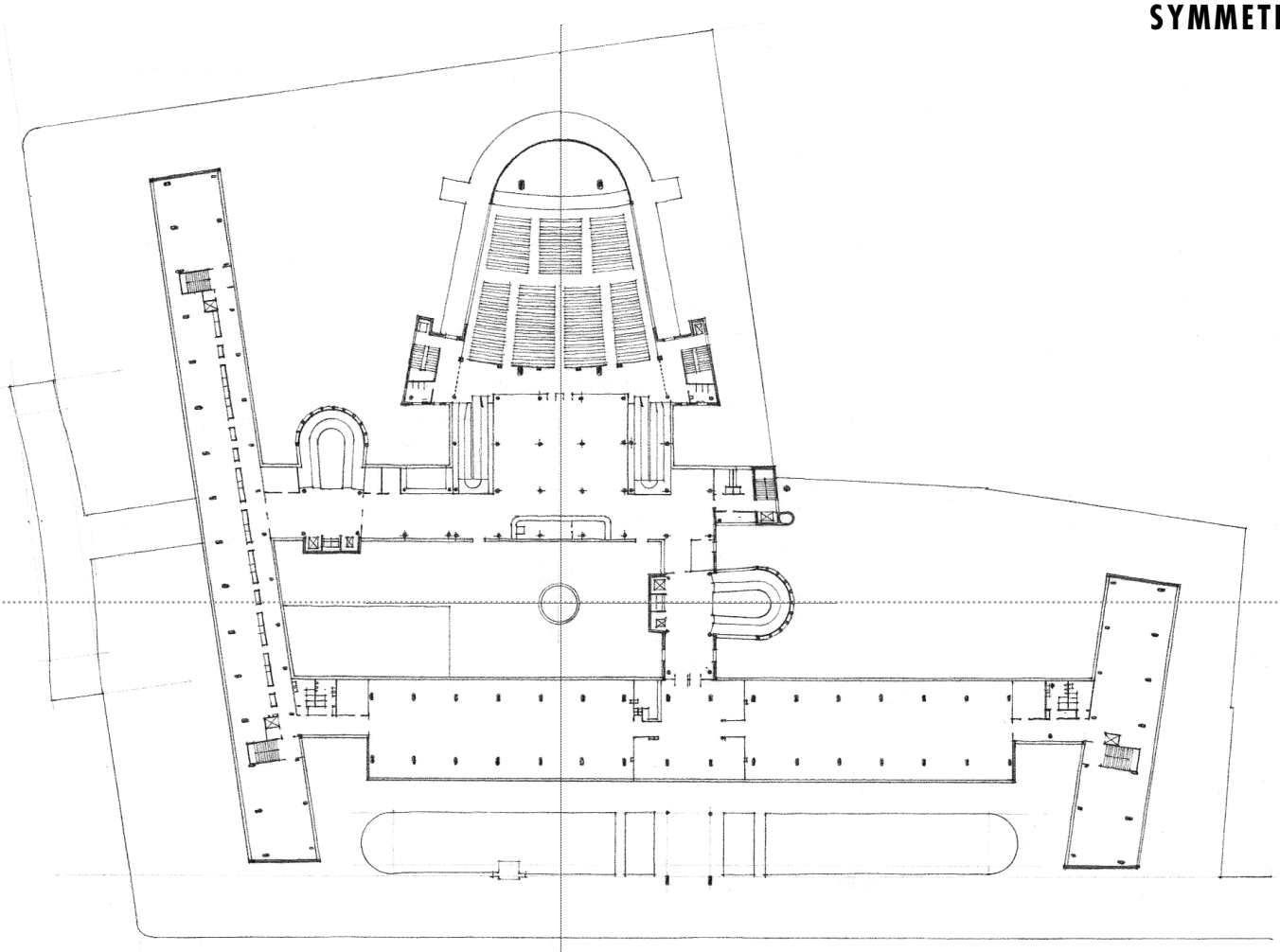
Palace of Diocletian, Spalato, Yugoslavia, c. A.D. 300



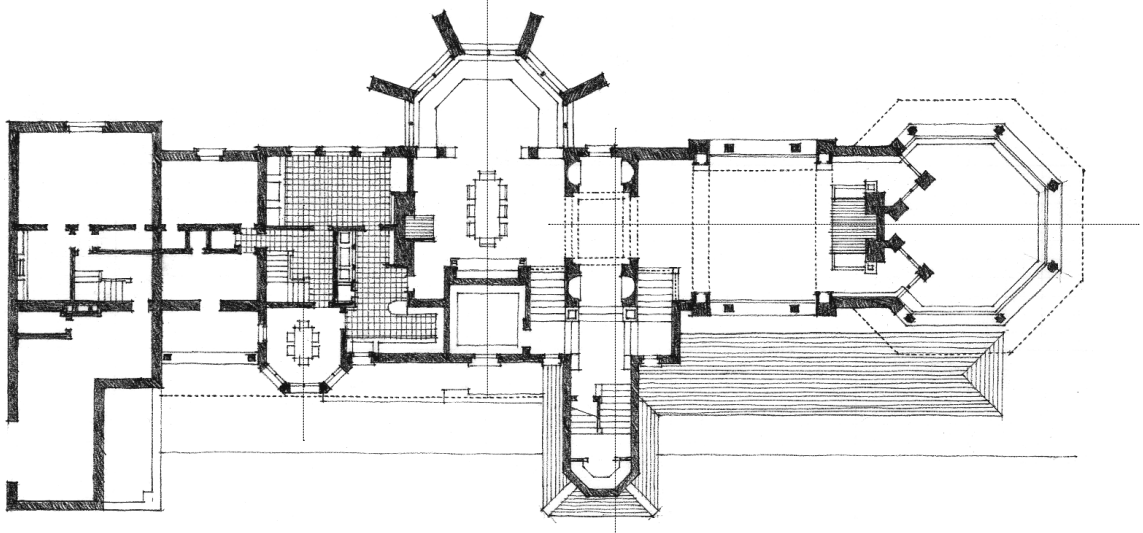
Unity Temple, Oak Park, Illinois, 1905–1907, Frank Lloyd Wright



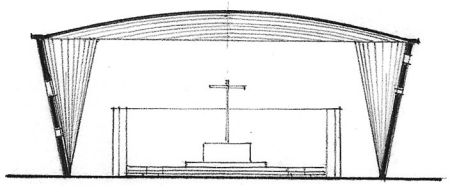
Multiple symmetries, both major and minor, can add complexity and hierarchy to a composition as well as accommodate programmatic and contextual requirements.

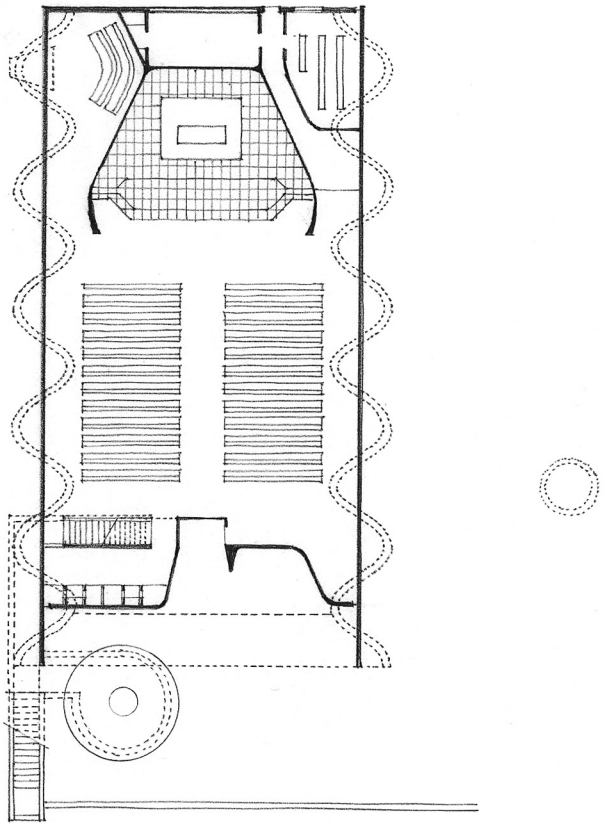


Third-floor plan, **Centrosoyus Building**, Kirova Ulitsa, Moscow, 1929–1933, Le Corbusier

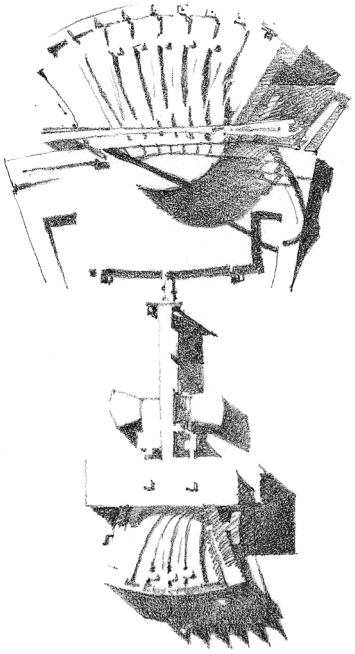


Husser House, Chicago, Illinois, 1899, Frank Lloyd Wright

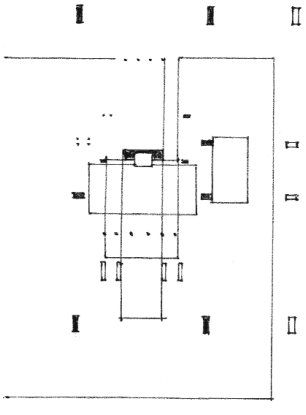


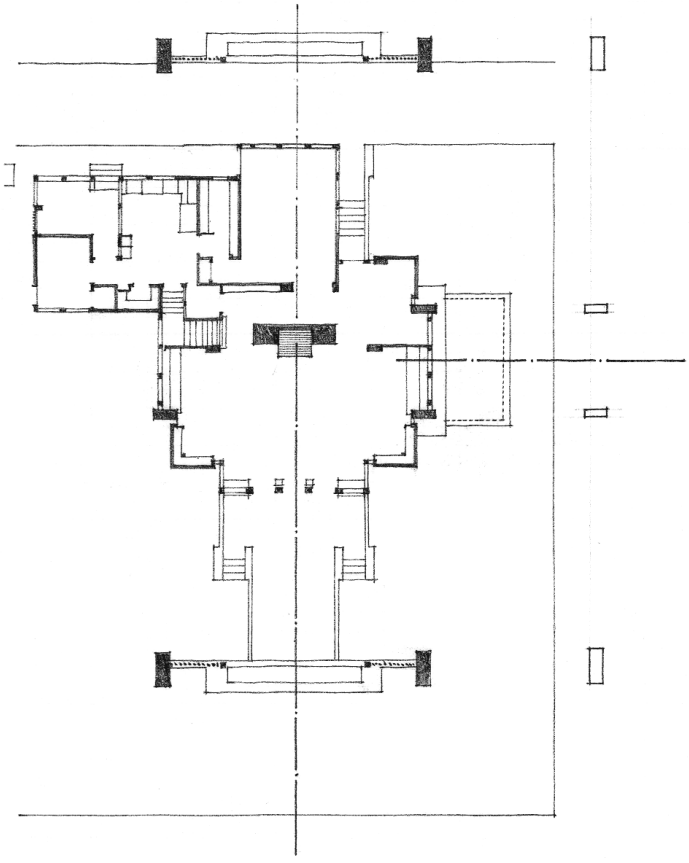


Church of Christ the Worker, Atlántida, Uruguay, Eladio Dieste, 1958–1960

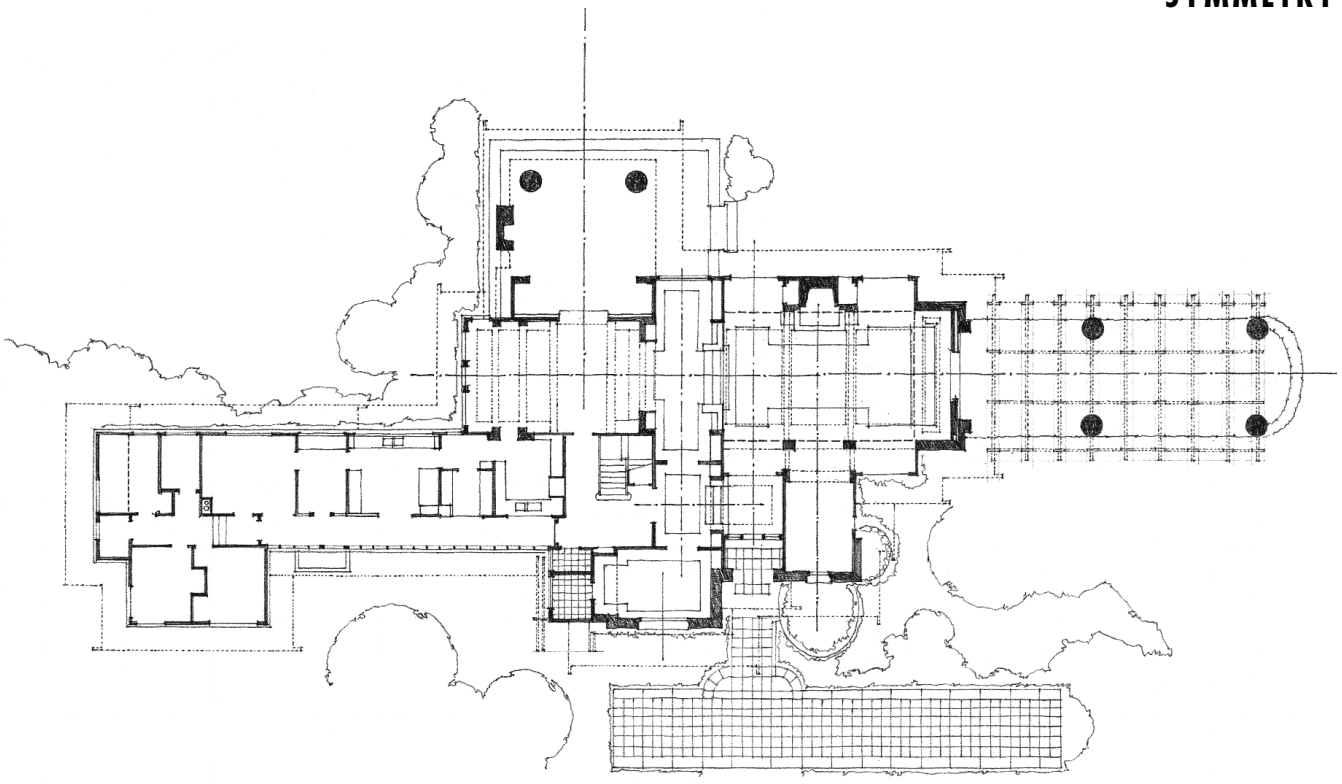


Palace of the Soviets (Competition), Le Corbusier, 1931

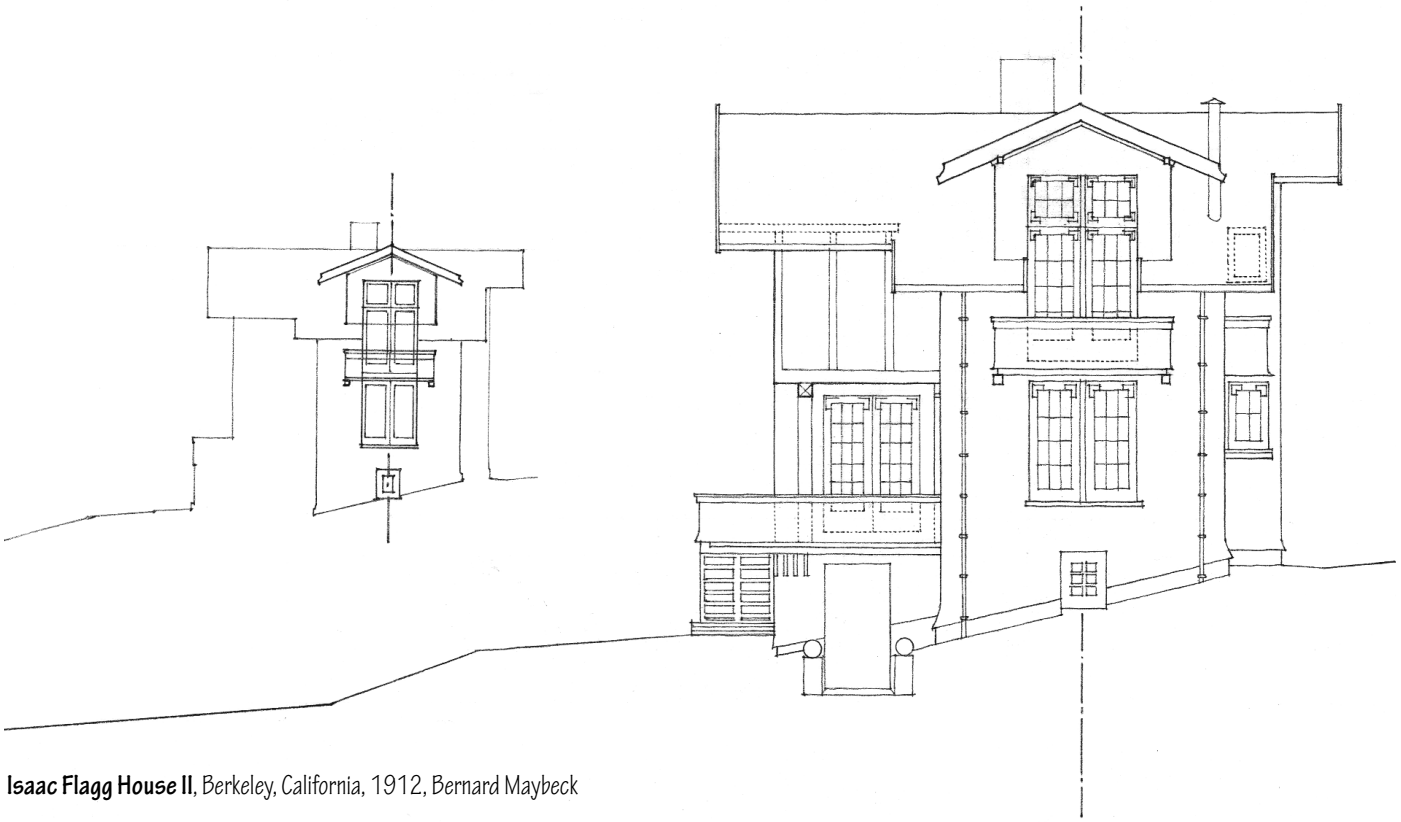




Robert W. Evans House, Chicago, Illinois, 1908, Frank Lloyd Wright

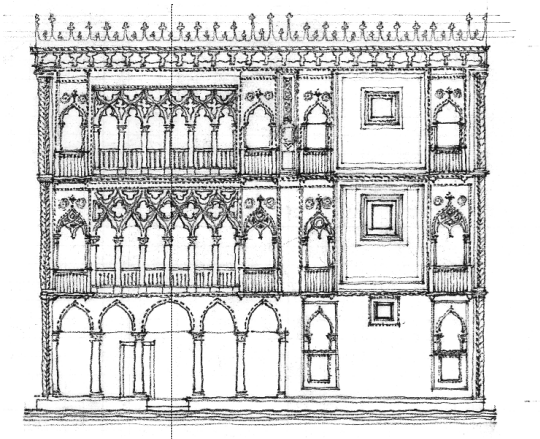


A.E. Bingham House, Near Santa Barbara, California, 1916, Bernard Maybeck

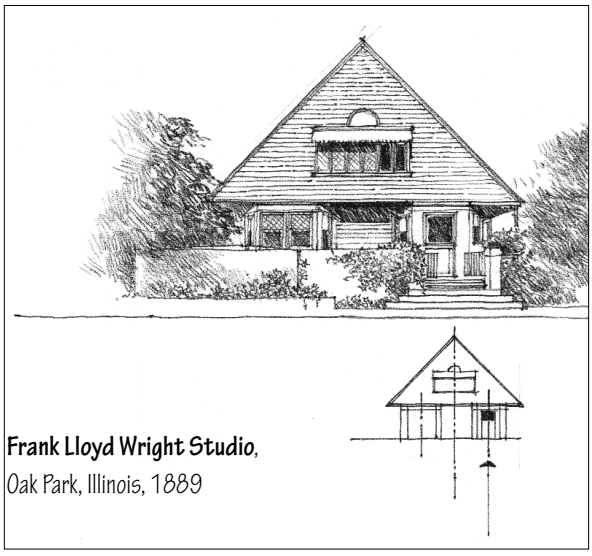


Isaac Flagg House II, Berkeley, California, 1912, Bernard Maybeck

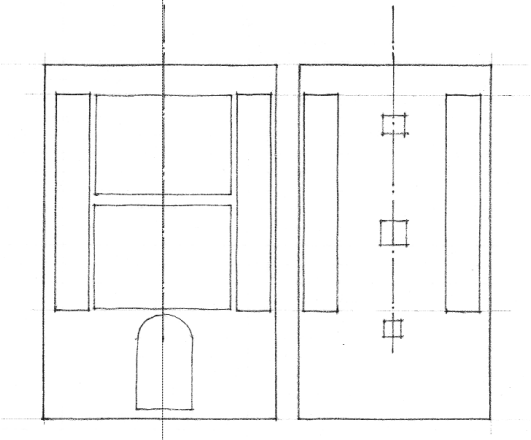
SYMMETRY

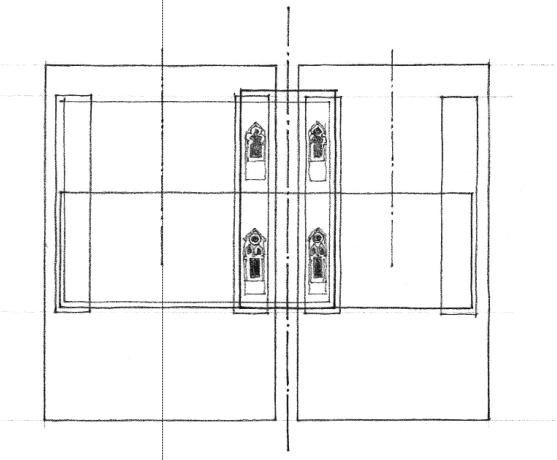


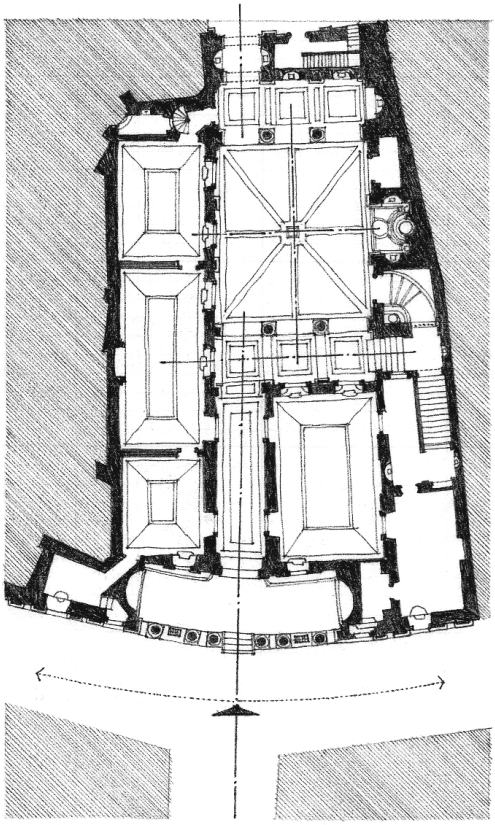
Ca d'Oro, Venice, 1428–1430, Giovanni and Bartolomeo Buon



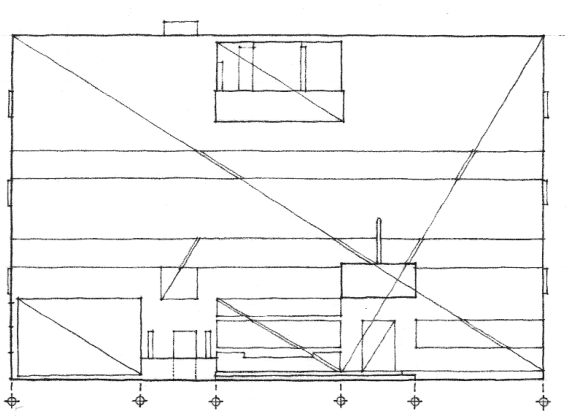
Frank Lloyd Wright Studio, Oak Park, Illinois, 1889

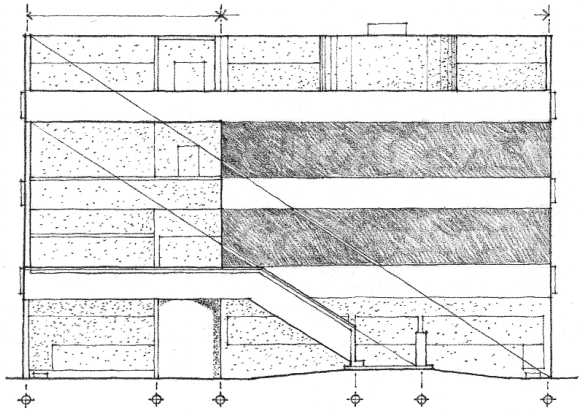


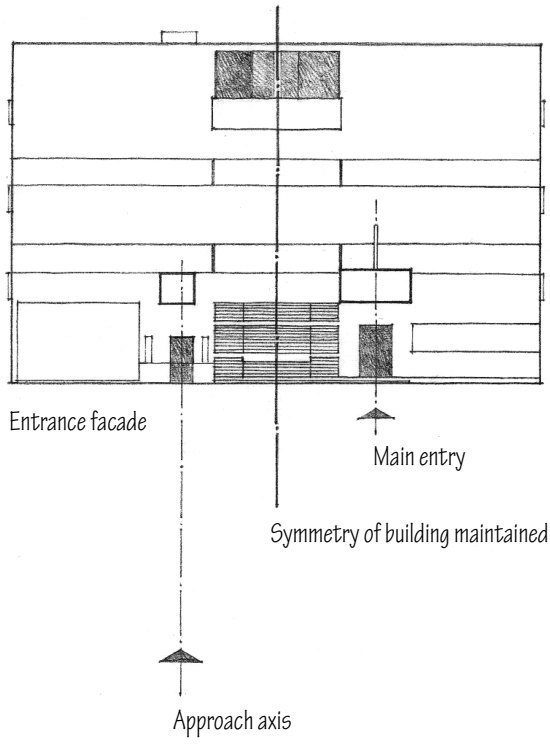


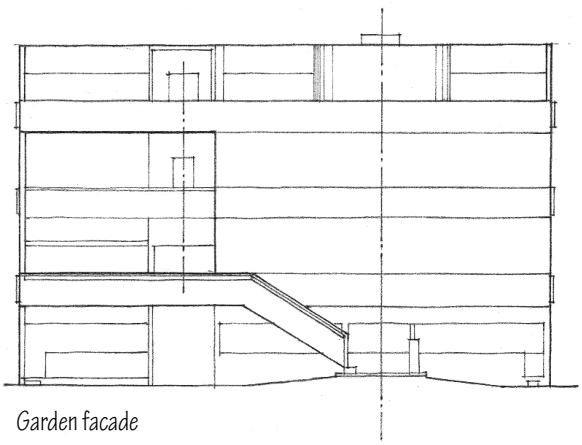


Palazzo Pietro Massimi, Rome, 1532–1536, Baldassare Peruzzi. A symmetrical facade leading into an asymmetrical interior.



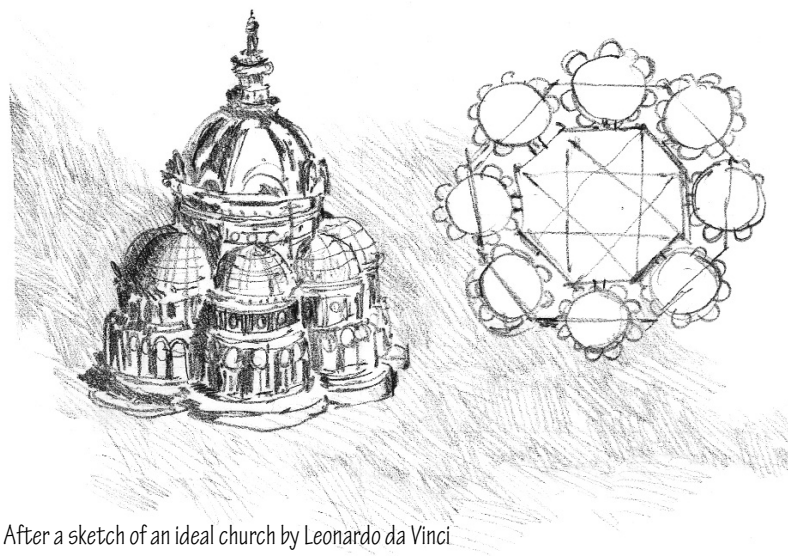






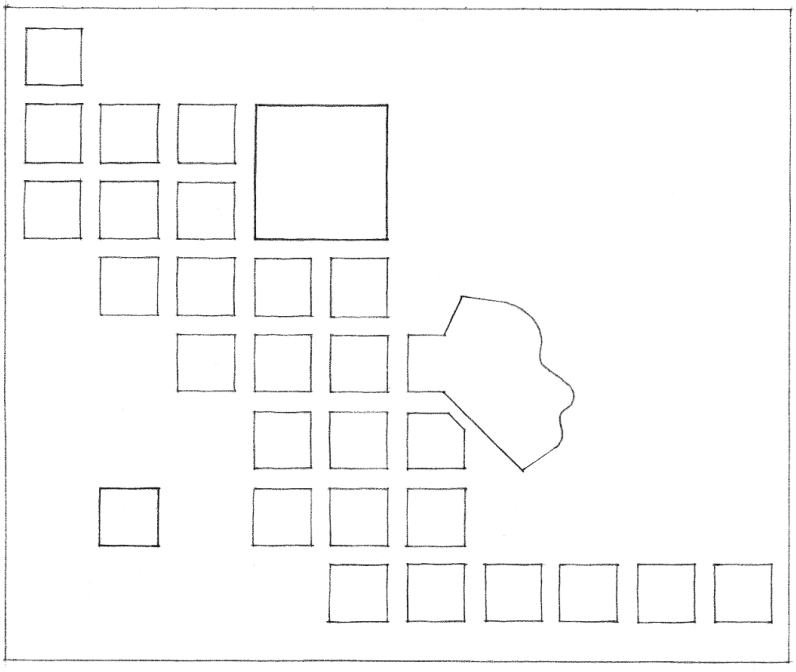
Villa *Garches*, Vaucresson, France, 1926–1927, Le Corbusier

HIERARCHY



After a sketch of an ideal church by Leonardo da Vinci

The principle of hierarchy implies that in most if not all architectural compositions, real differences exist among their forms and spaces. These differences reflect the degree of importance of these forms and spaces, as well as the functional, formal, and symbolic roles they play in the organization. The value system by which relative importance is measured will of course depend on the specific situation, the needs and desires of the users, and the decisions of the designer. The values expressed may be individual or collective, personal or cultural. In any case, the manner in which the functional or symbolic differences among a building's elements are revealed is critical to the establishment of a visible, hierarchical order among its forms and spaces.



For a form or space to be articulated as being important or significant to an organization, it must be made uniquely visible. This visual emphasis can be achieved by endowing a form or shape with:

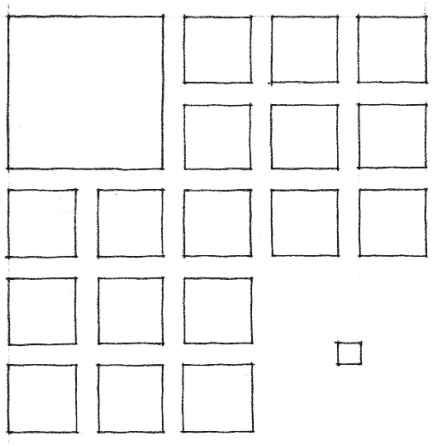
- Exceptional size
- A unique shape
- A strategic location

In each case, the hierarchically important form or space is given meaning and significance by being an exception to the norm, an anomaly within an otherwise regular pattern.

In an architectural composition, there can be more than a single dominant element. Secondary points of emphasis that have less attention value than the primary focal point create visual accents. These distinctive but subordinate elements can both accommodate variety and create visual interest, rhythm, and tension in a composition. If carried too far, however, this interest may be replaced by confusion. When everything is emphasized, nothing is emphasized.

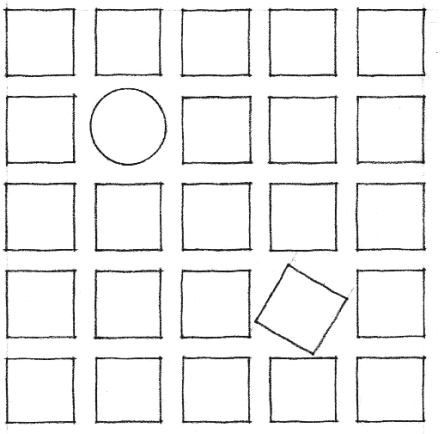
Hierarchy by Size

A form or space may dominate an architectural composition by being significantly different in size from all the other elements in the composition. Normally, this dominance is made visible by the sheer size of an element. In some cases, an element can dominate by being significantly smaller than the other elements in the organization, but placed in a well-defined setting.



Hierarchy by Shape

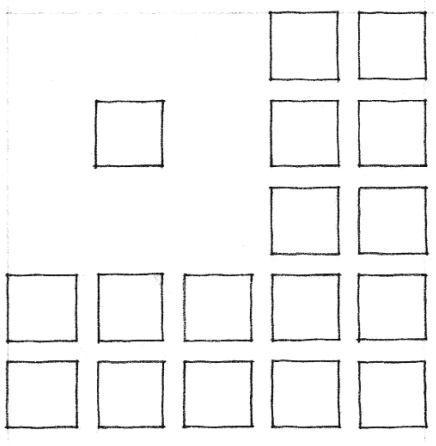
A form or space can be made visually dominant and thus important by clearly differentiating its shape from that of the other elements in the composition. A discernible contrast in shape is critical, whether the differentiation is based on a change in geometry or regularity. Of course, it is also important that the shape selected for the hierarchically significant element be compatible with its functional use.



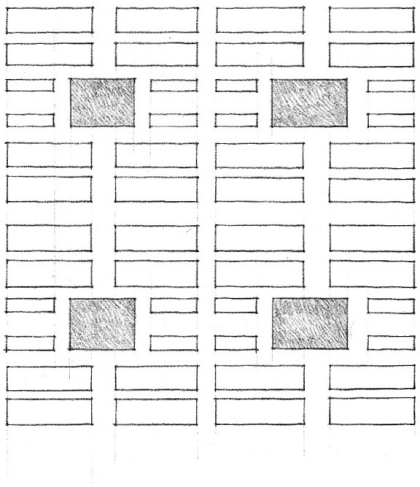
Hierarchy by Placement

A form or space may be strategically placed to call attention to itself as being the most important element in a composition. Hierarchically important locations for a form or space include:

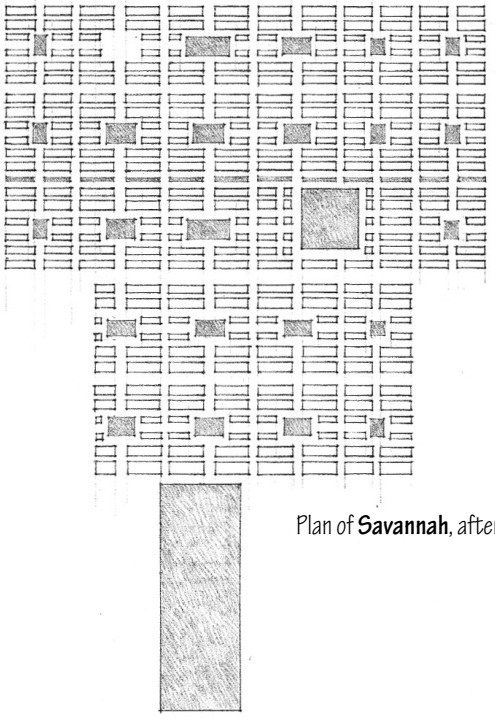
- The termination of a linear sequence or axial organization
- The centerpiece of a symmetrical organization
- The focus of a centralized or radial organization
- Being offset above, below, or in the foreground of a composition



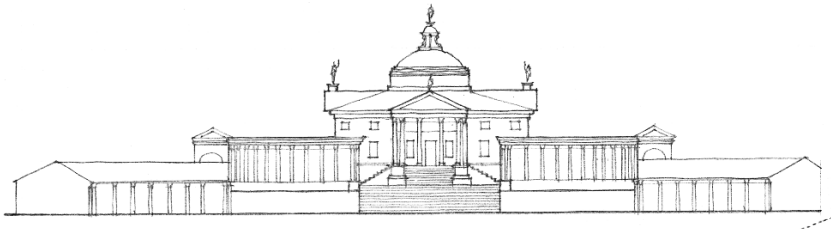
HIERARCHY



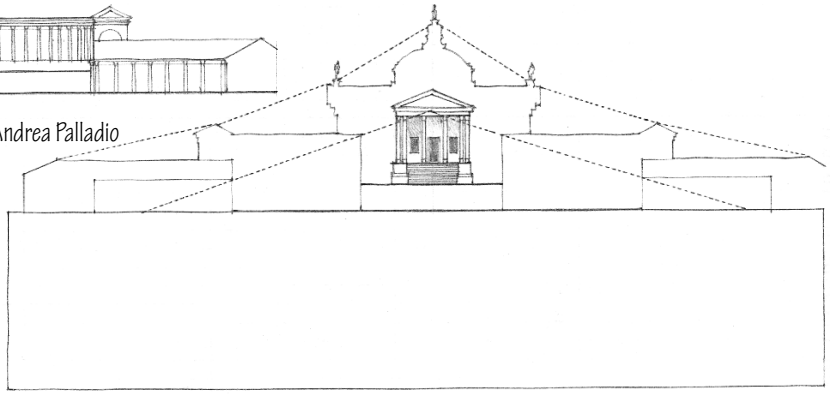
Plan for **Savannah**, *Georgia*, 1733, *James Oglethorpe*

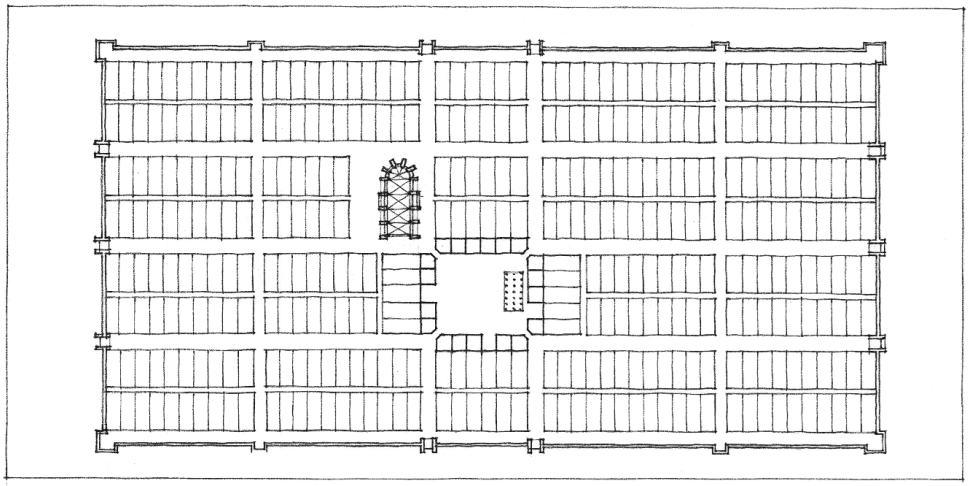


Plan of **Savannah**, *after 1856*

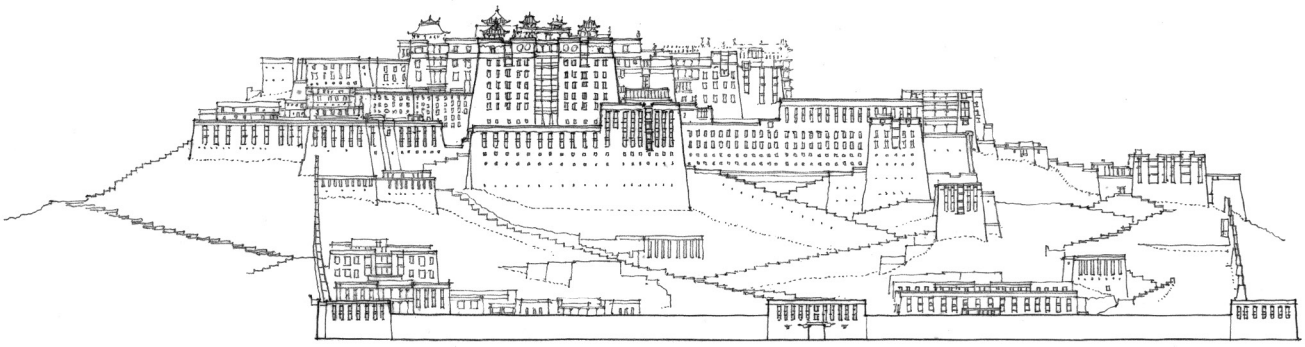


Villa Trissino at Meledo, From *The Four Books on Architecture*, Andrea Palladio

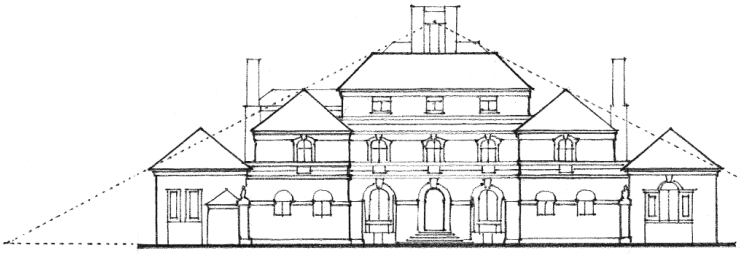




Plan of **Montfazier**, France,
a Medieval town founded in 1284

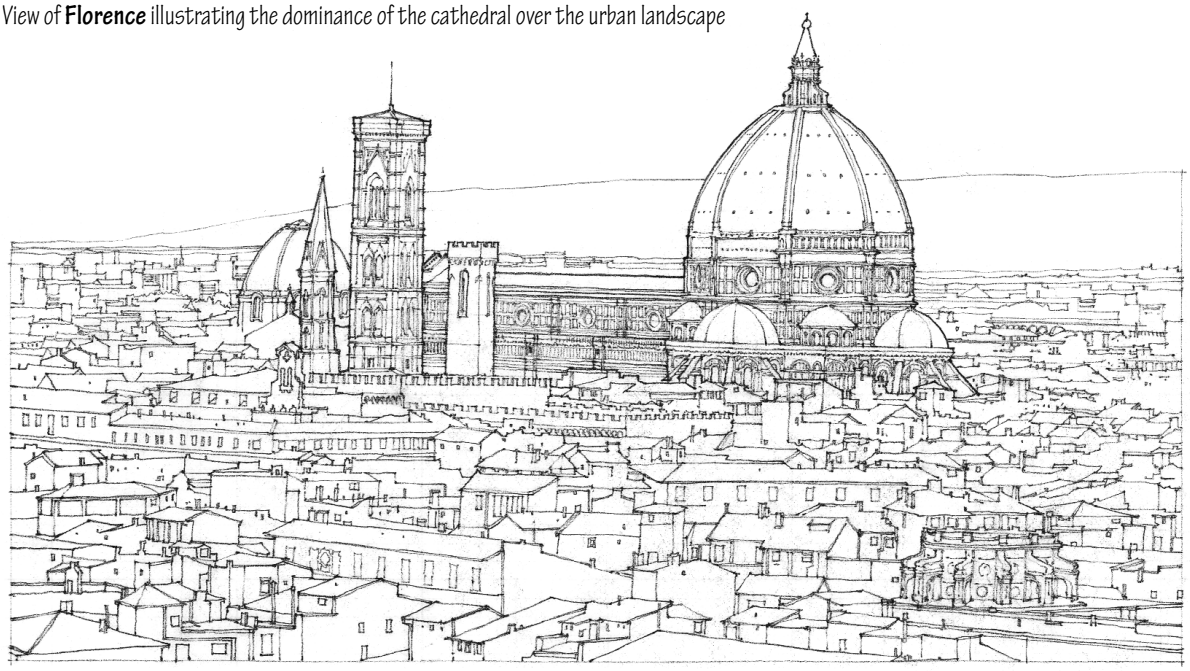


Potala Palace, Lhasa, Tibet (China), 17th century

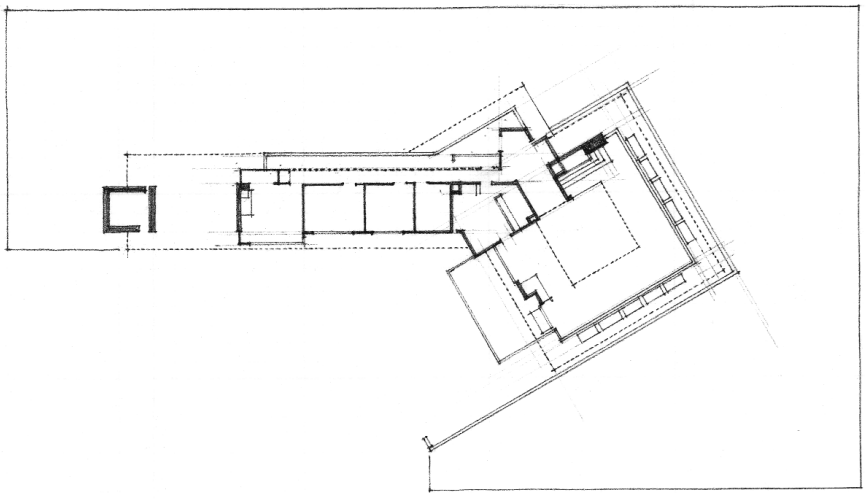


Heathcote (Hemingway House), Ilkley, Yorkshire, England, 1906, Sir Edwin Lutyens

View of **Florence** illustrating the dominance of the cathedral over the urban landscape

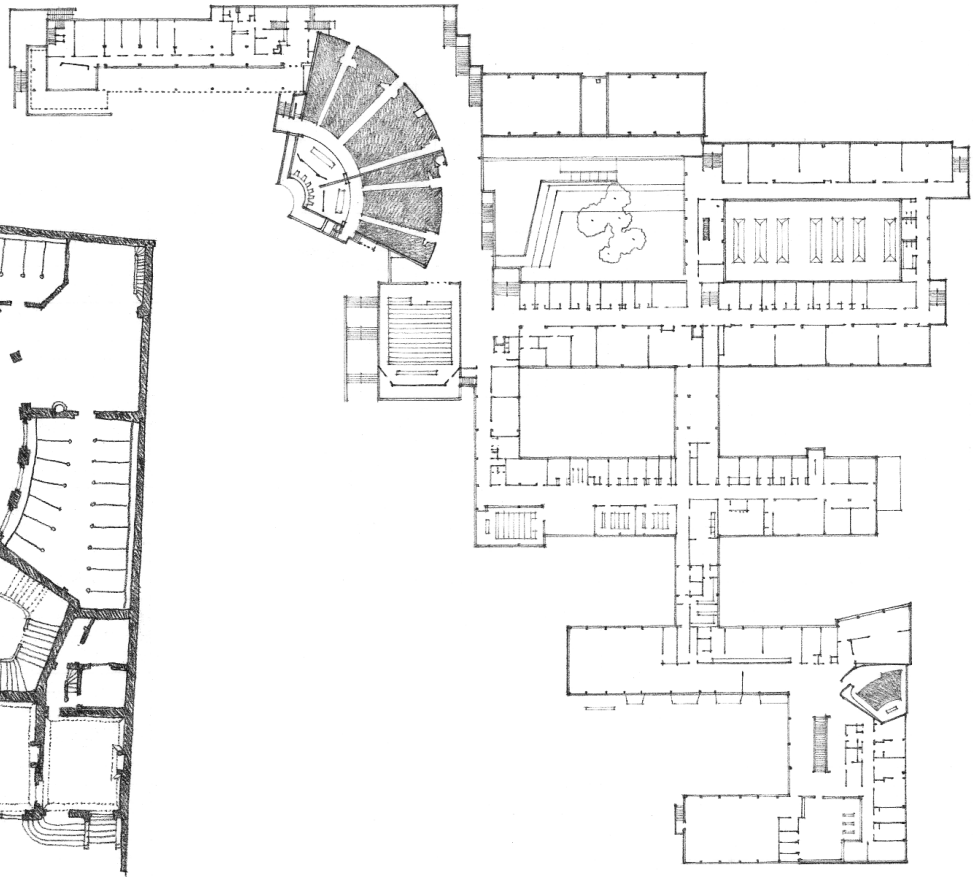


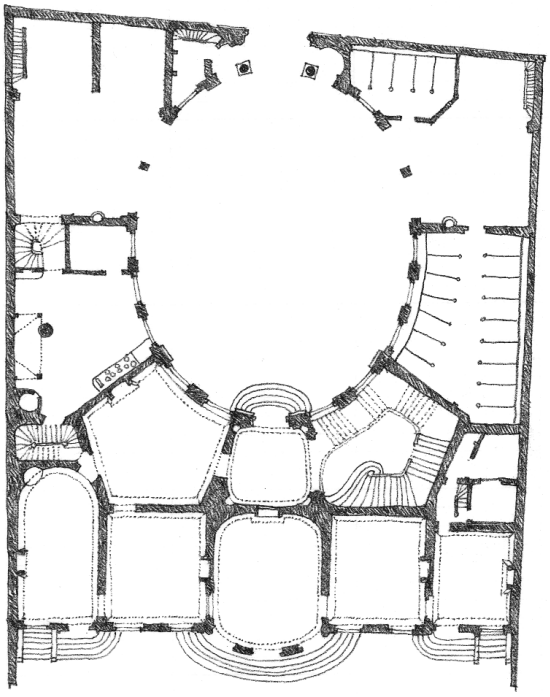
HIERARCHY



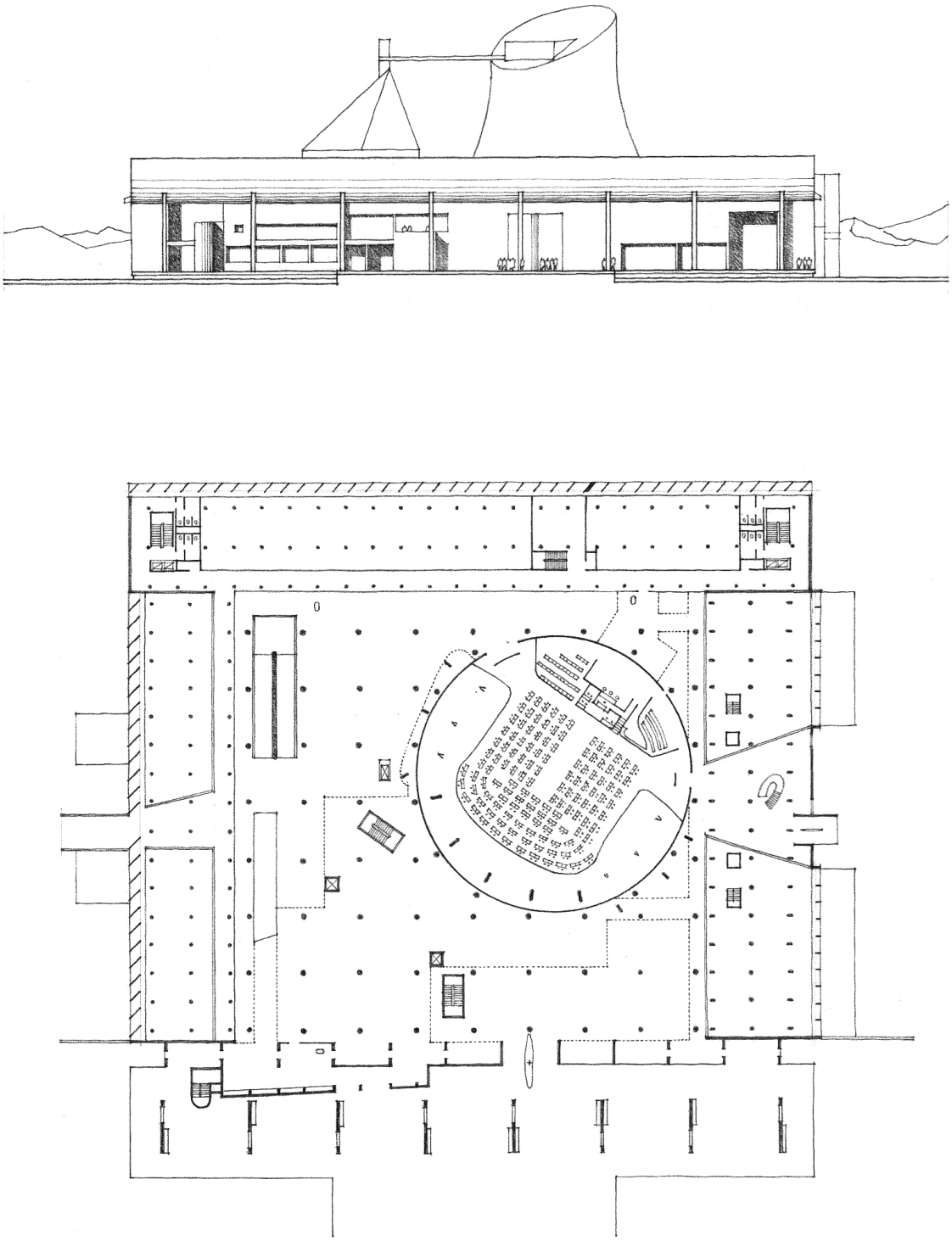
Lowell Walter House, Quasqueton, Iowa, 1949, Frank Lloyd Wright

Institute of Technology, Otaniemi, Finland, 1955–1964, Alvar Aalto

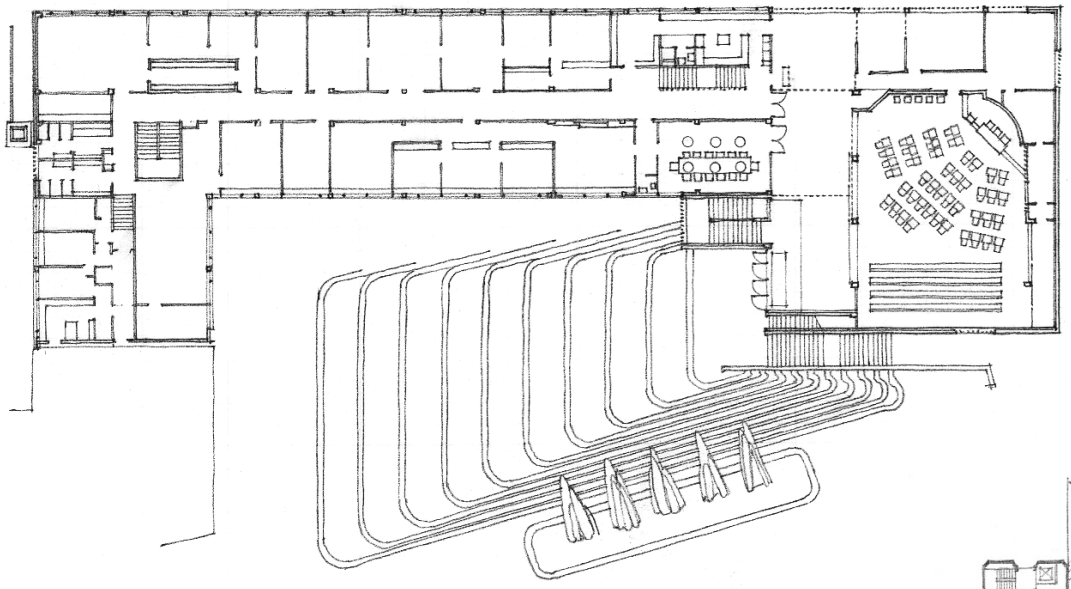




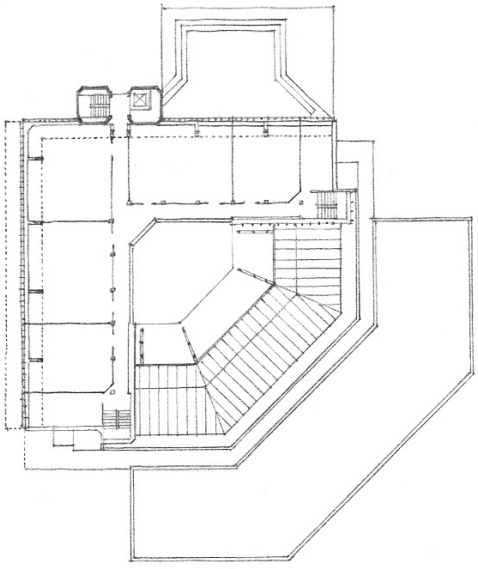
Hôtel Amelot, Paris, 1710–1713, Germain Boffrand



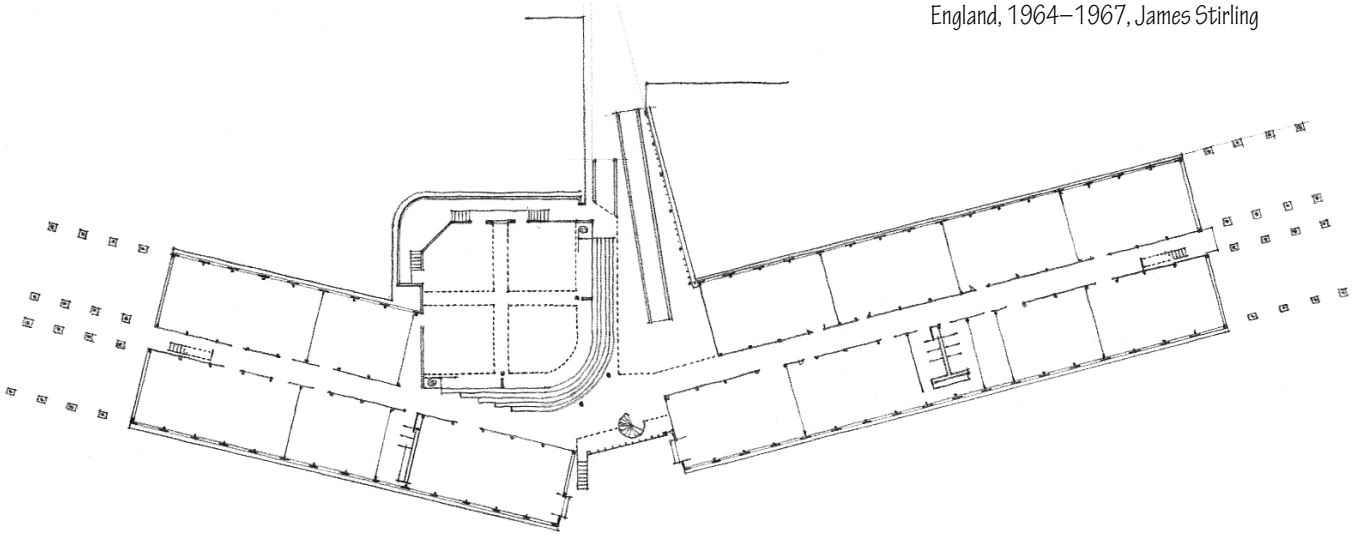
Legislative Assembly Building, Chandigarh, Capitol Complex of Punjab, India, 1956–1959, Le Corbusier



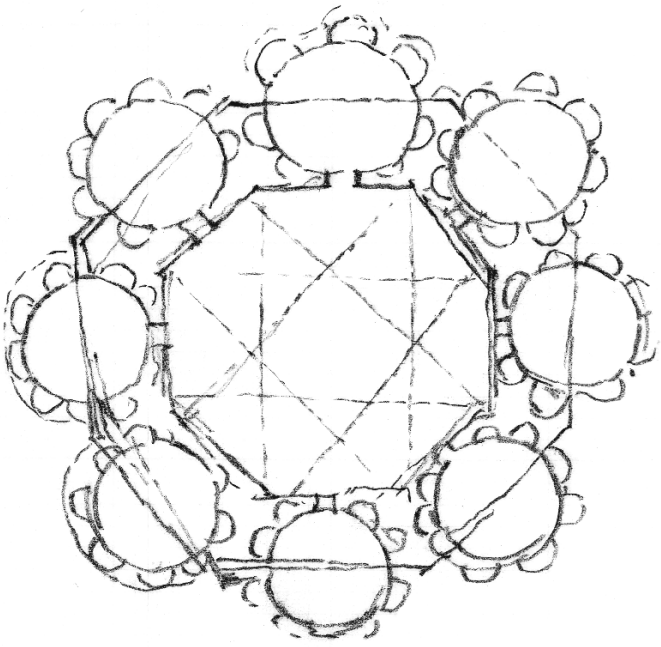
Town Hall, Seinäjoki, 1961–1965, Alvar Aalto



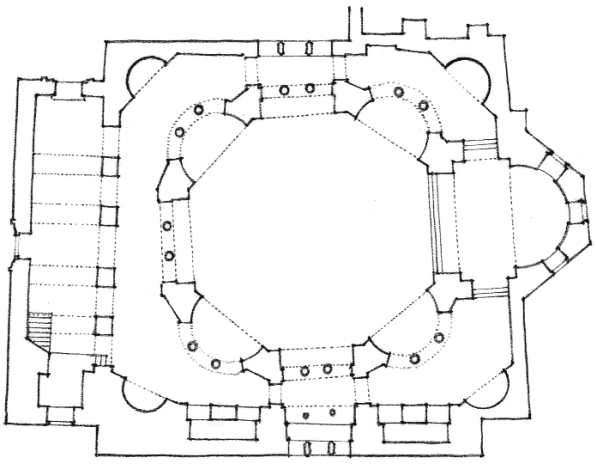
History Faculty Building, Cambridge University, England, 1964–1967, James Stirling



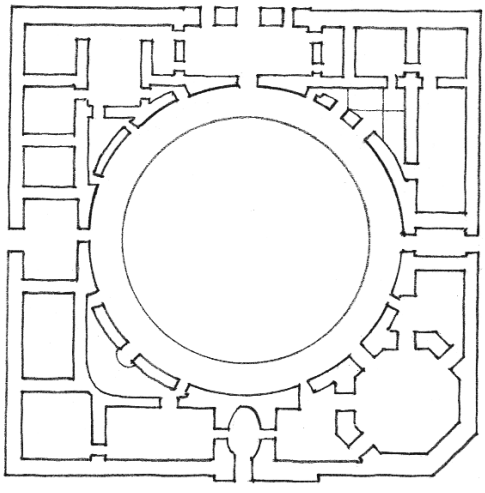
Olivetti Training School, Haslemere, England, 1969–1972, James Stirling



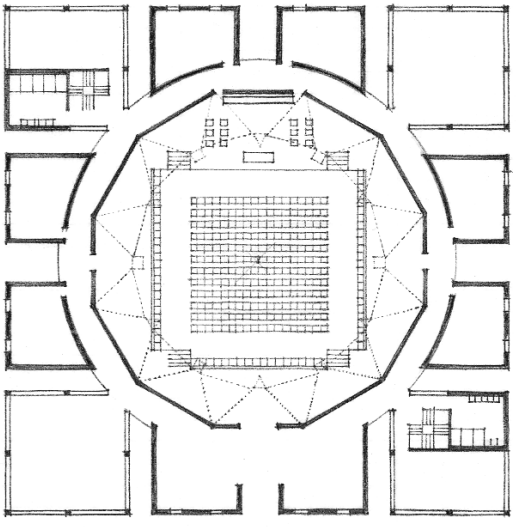
Plan of an Ideal Church, *c.* 1490, *Leonardo da Vinci*



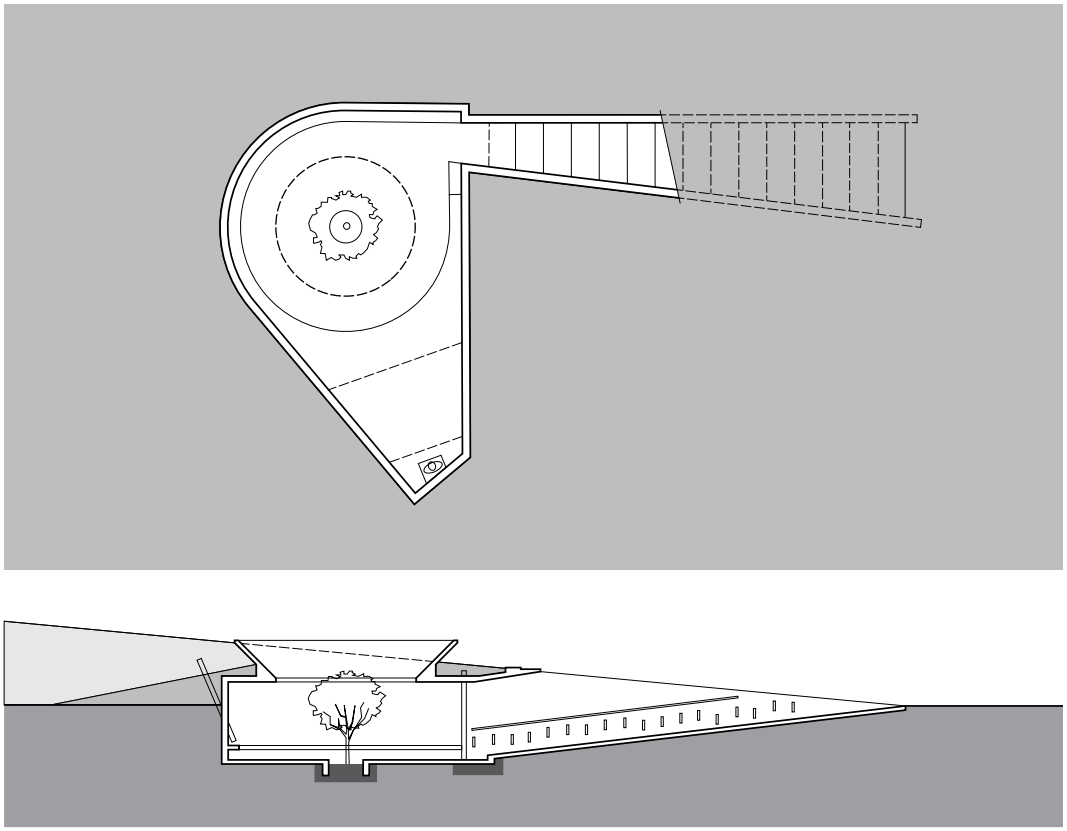
S.S. Sergius and Bacchus, *Constantinople (Istanbul), A.D. 525–530*



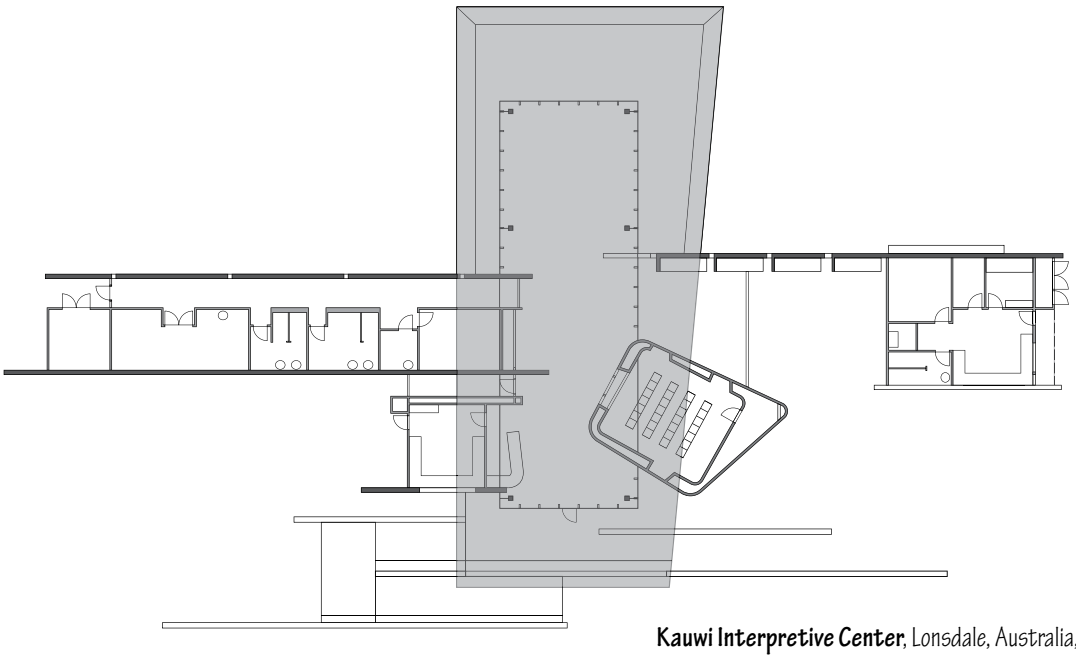
Palace of Charles V, *Granada, 1527–1568, Pedro Machuca*



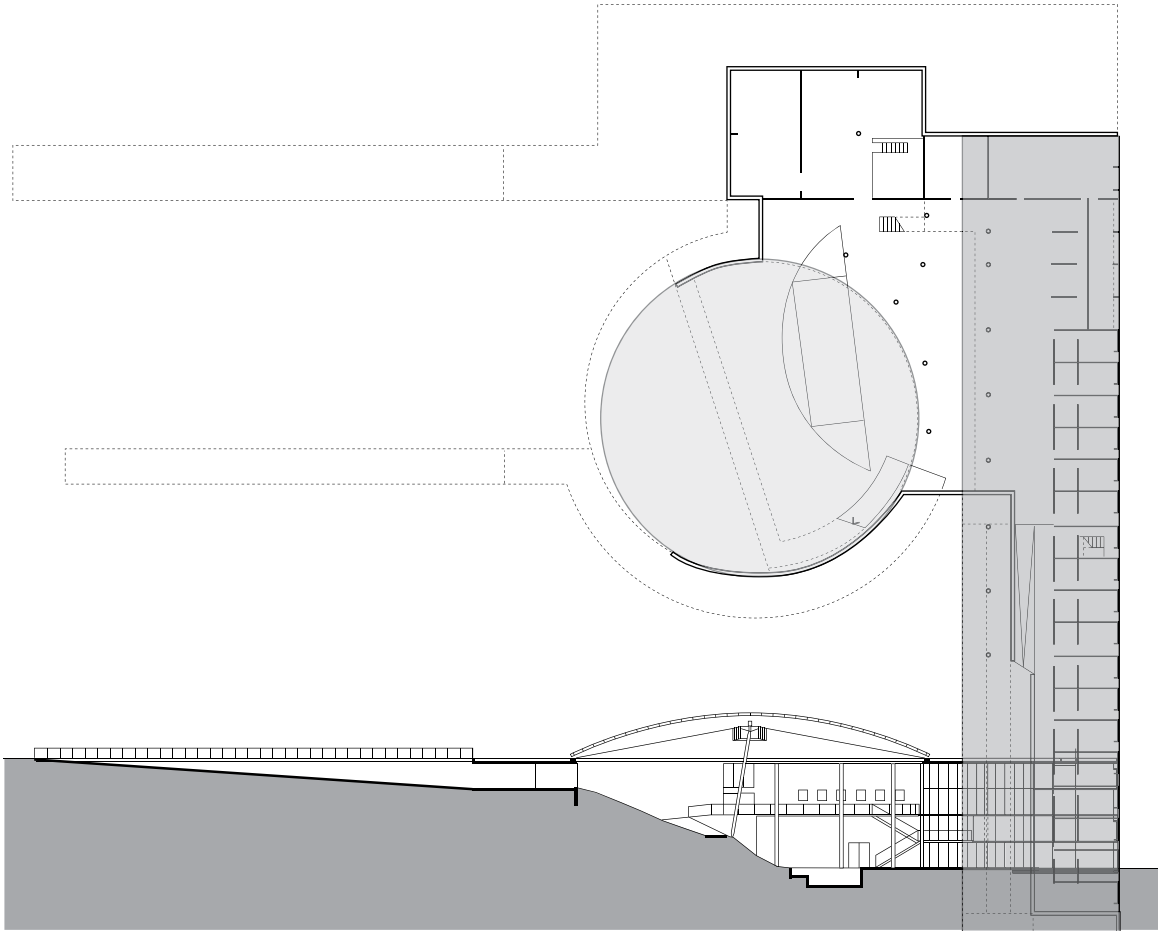
First Unitarian Church, *First Design, Rochester, New York, 1959, Louis Kahn*



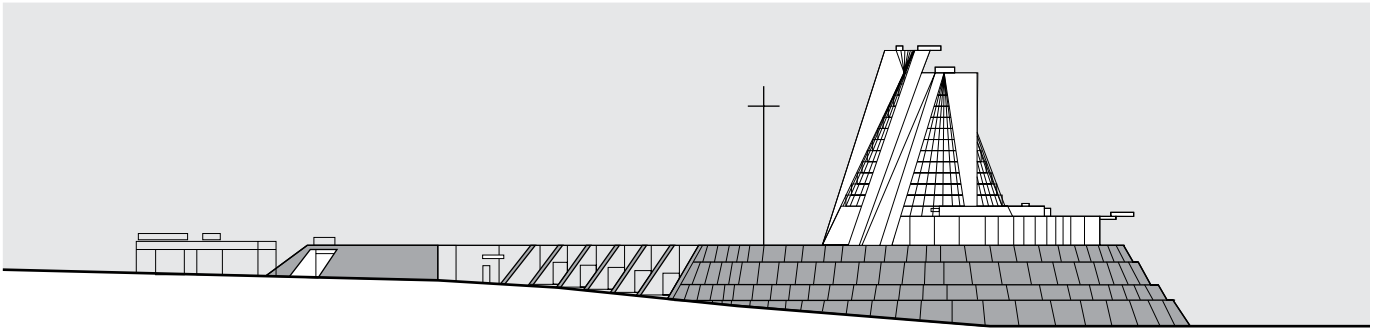
M9 (Memorial 9), *Santiago, Chile, 2011, Gonzalo Mardones Viviani*



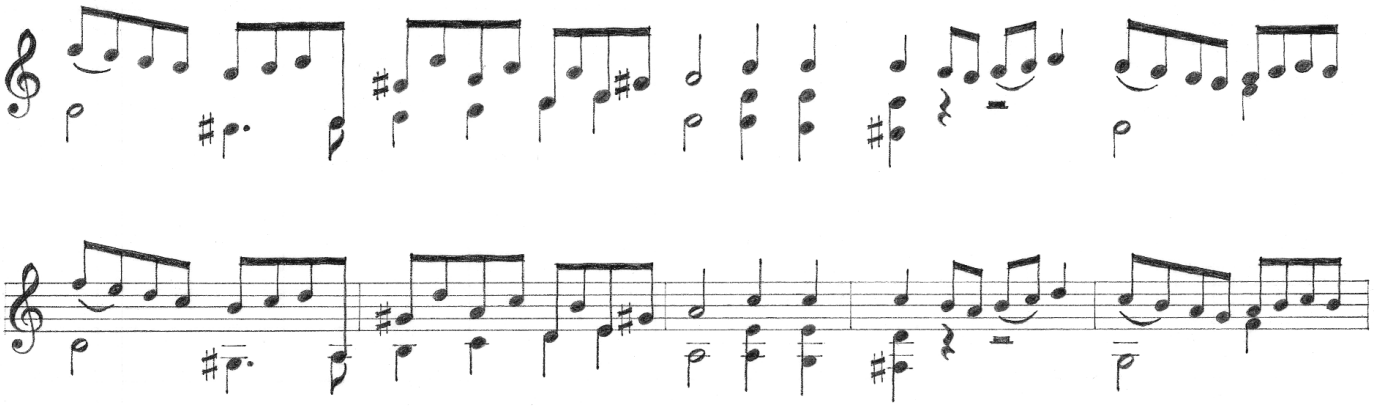
Kauwi Interpretive Center, *Lonsdale, Australia, 2012, Woodhead*

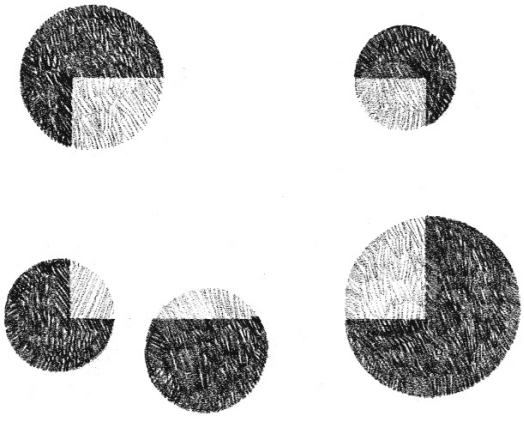


ESO (European Southern Observatory) Hotel, Cerro Paranal, Atacama Desert, Chile, 1999–2002, Auer + Weber Associates



Iglesia San Josemaría Escrivá, Alvaro Obregon, Mexico, 2009, Sordo Madaleno Arquitectos

DATUM

Excerpt from ***Gavotte I*, *Sixth Cello Suite***, by Johann Sebastian Bach (1685–1750). Transcribed for classical guitar by Jerry Snyder.



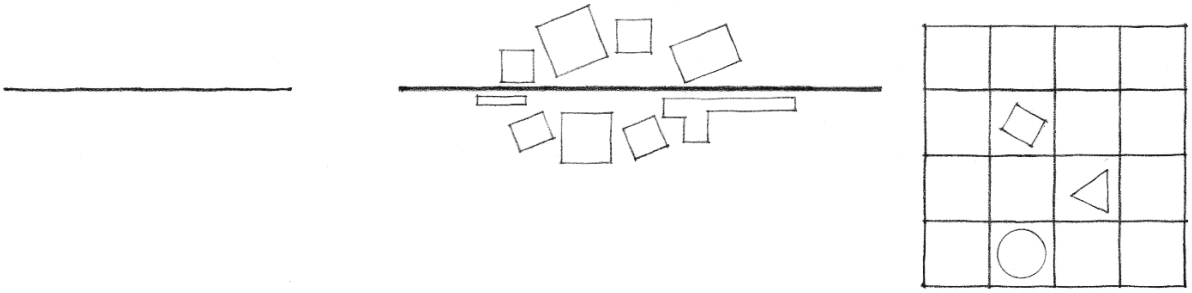
A datum refers to a line, plane, or volume of reference to which other elements in a composition can relate. It organizes a random pattern of elements through its regularity, continuity, and constant presence. For example, the lines of a musical staff serve as a datum in providing the visual basis for reading notes and the relative pitches of their tones. The regularity of their spacing and their continuity organizes, clarifies, and accentuates the differences between the series of notes in a musical composition.

A preceding section illustrated the ability of an axis to organize a series of elements along its length. In effect, the axis was serving as a datum. A datum, however, need not be a straight line. It can also be planar or volumetric in form.

To be an effective ordering device, a linear datum must have sufficient visual continuity to cut through or bypass all of the elements being organized. If planar or volumetric in form, a datum must have sufficient size, closure, and regularity to be seen as a figure that can embrace or gather together the elements being organized within its field.

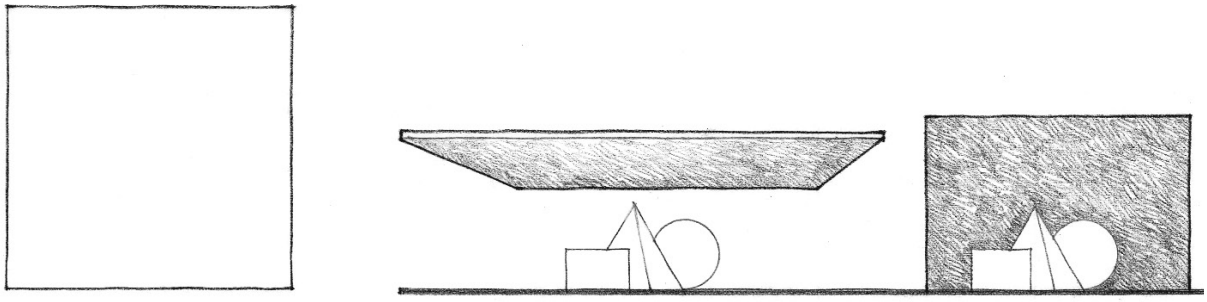
Given a random organization of dissimilar elements, a datum can organize the elements in the following ways:

Line



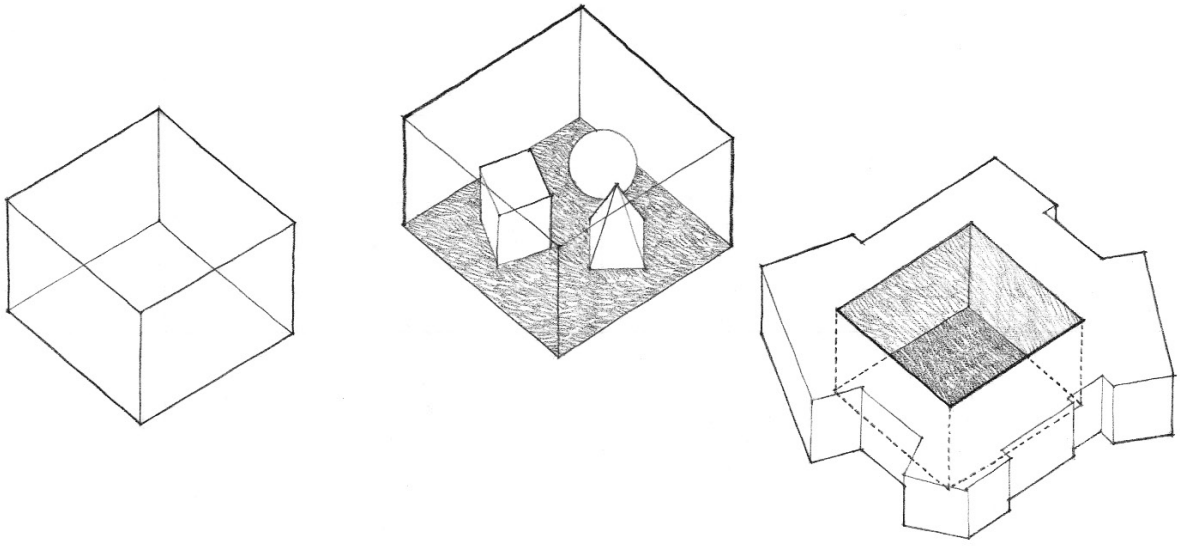
A line can cut through or form a common edge for the pattern, while a grid of lines can form a neutral, unifying field for the pattern.

Plane

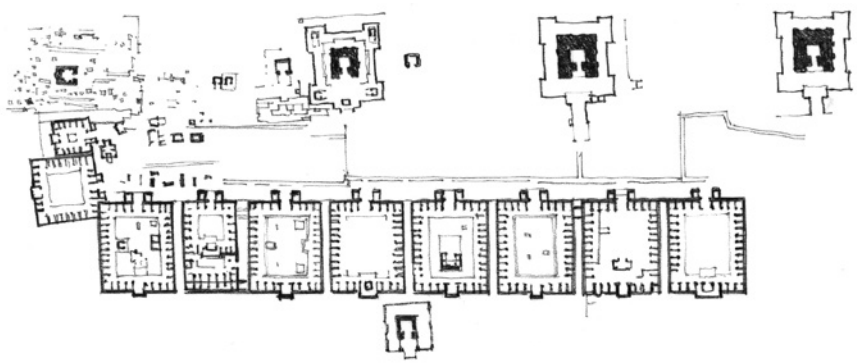


A plane can gather the pattern of elements beneath it or serve as an encompassing background for the elements and frame them in its field.

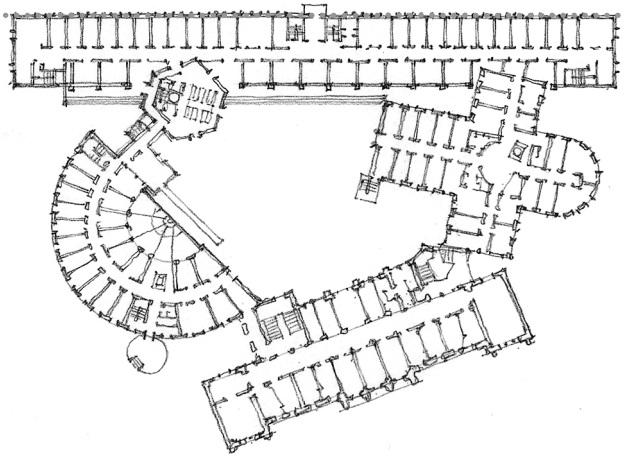
Volume



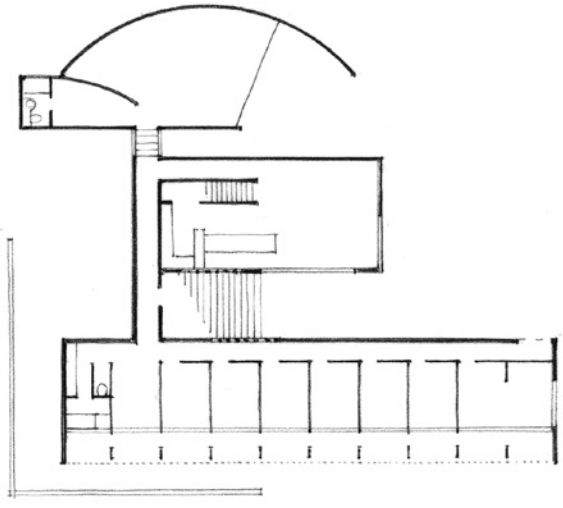
A volume can collect the pattern of elements within its boundaries or organize them along its perimeter.



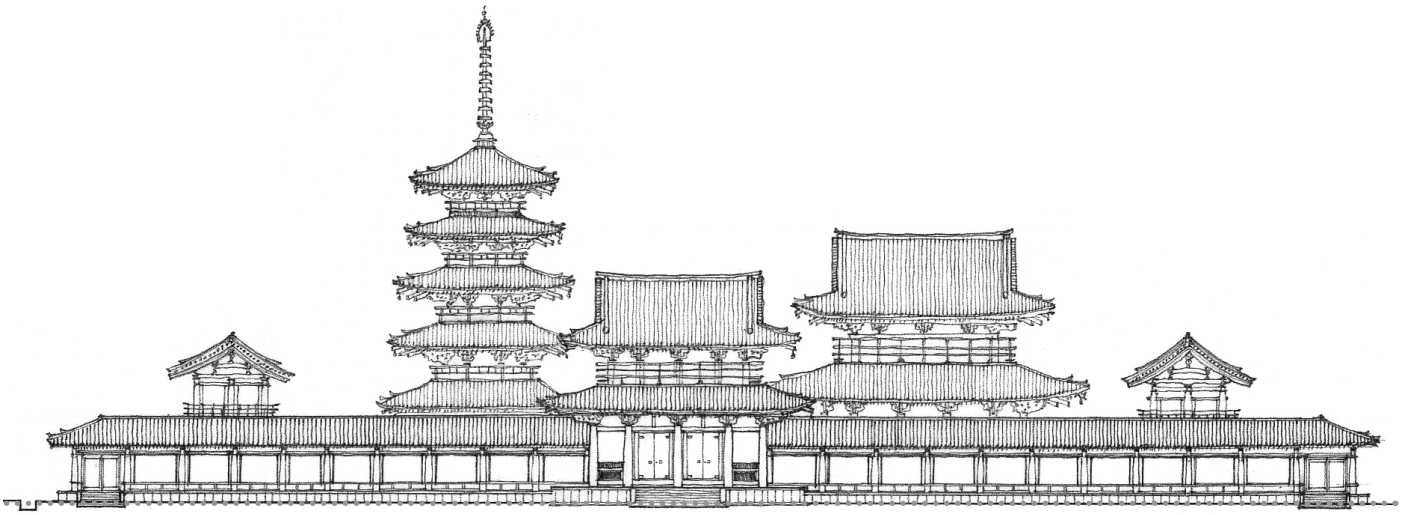
Nalanda Mahavihara, Bihar, India, 6th–7th century A.D.



Social Science Research Center, Berlin, Germany, 1981, James Stirling

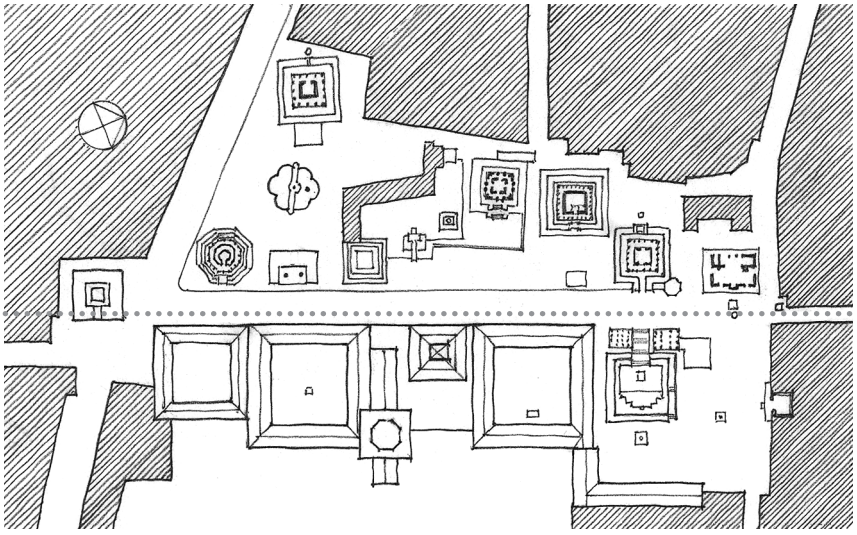


Koshino House, Ashiya, Hyogo Prefecture, Japan, 1979–1984, Tadao Ando



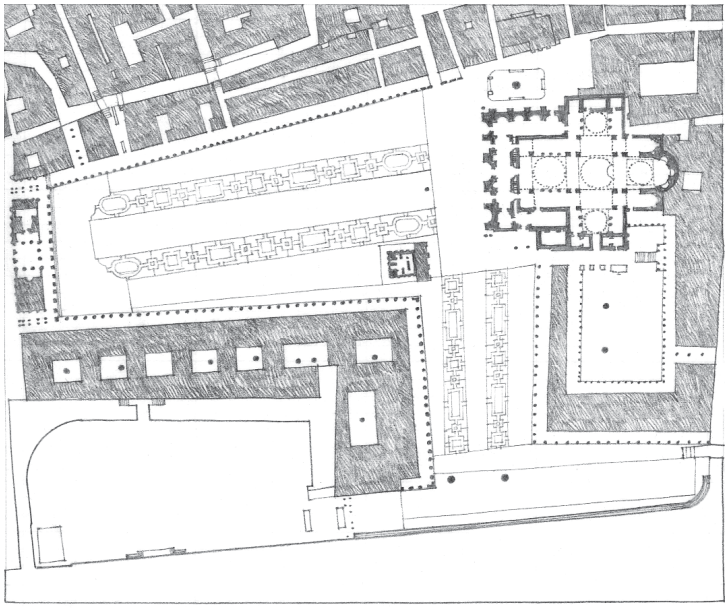
West Precinct, Horyu-Ji Temple, Nara Prefecture, Japan, A.D. 607–746

Arcades unify the facades of houses that front the town square of Telo, Czechoslovakia.

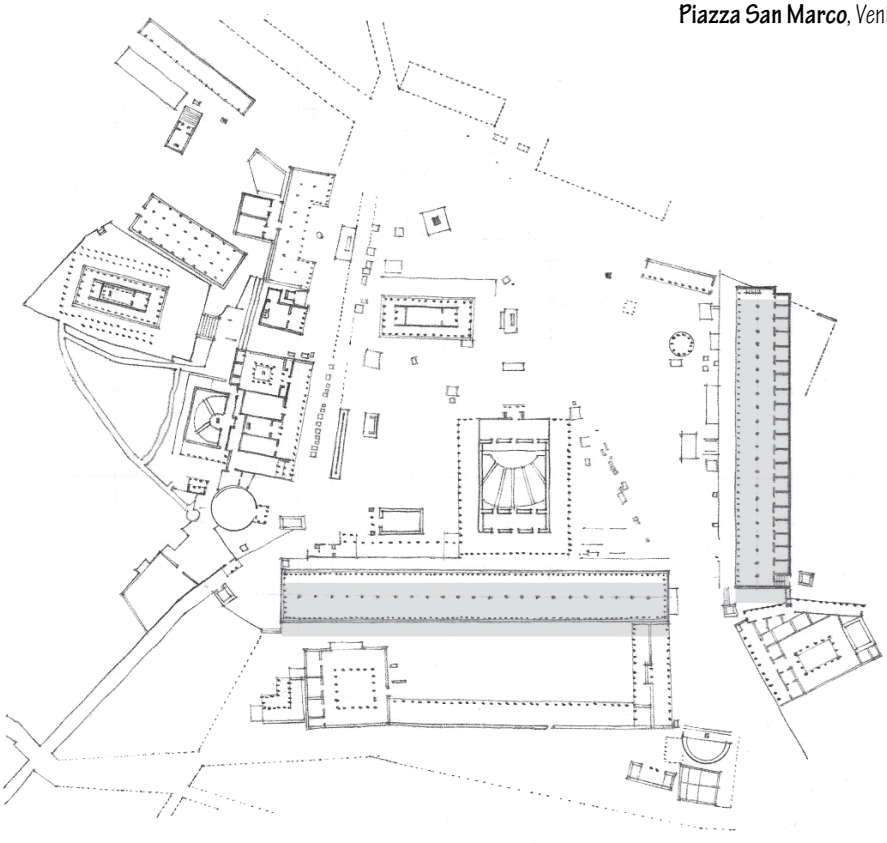


Durbar Square, Patan, Nepal, renovated 17th century

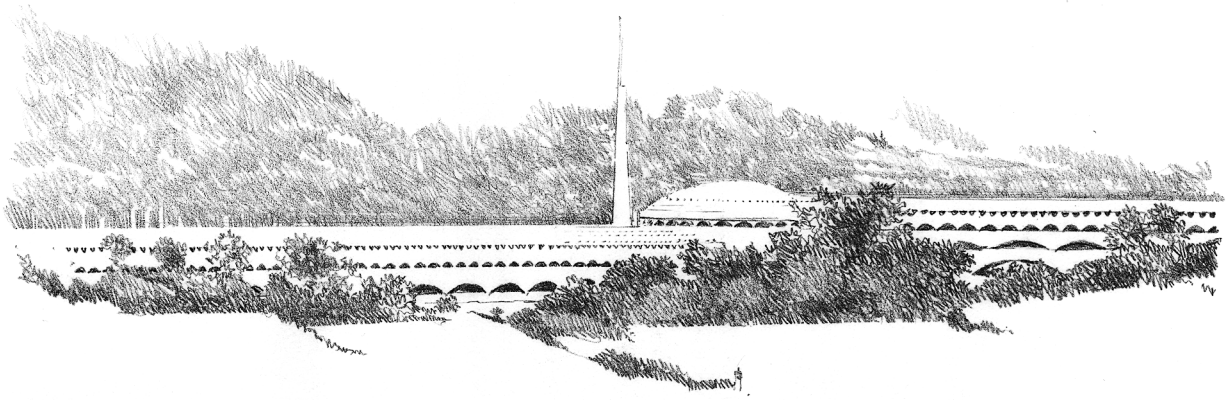
Plan of Safavid **Isfahan**, Iran



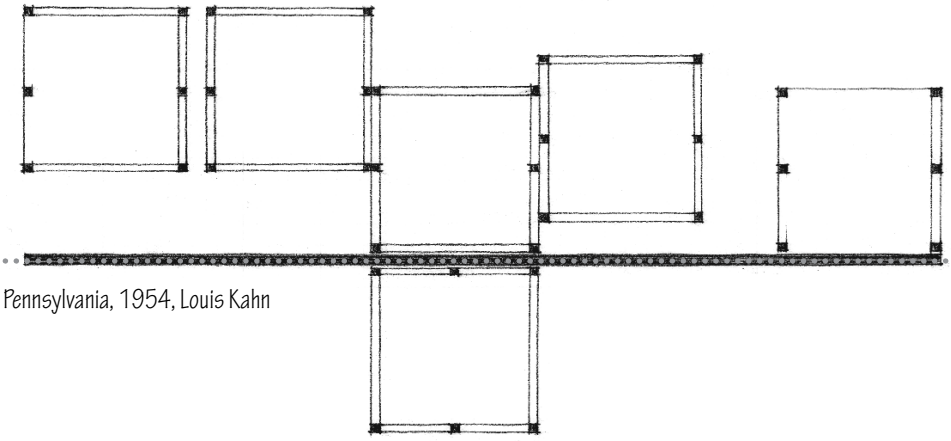
Piazza San Marco, Venice



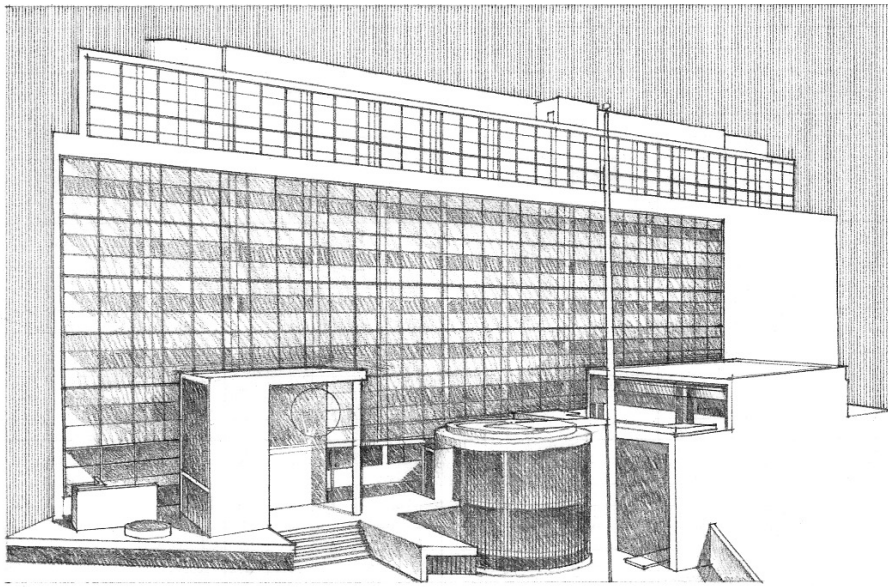
Plan of the **Agora**, Athens



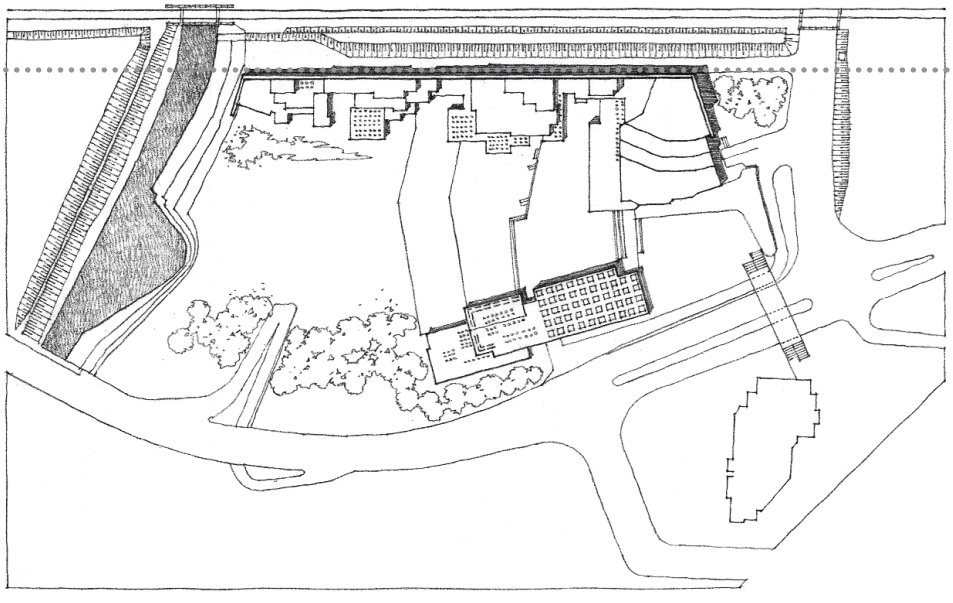
Marin County Civic Center, San Rafael, California, 1957, Frank Lloyd Wright



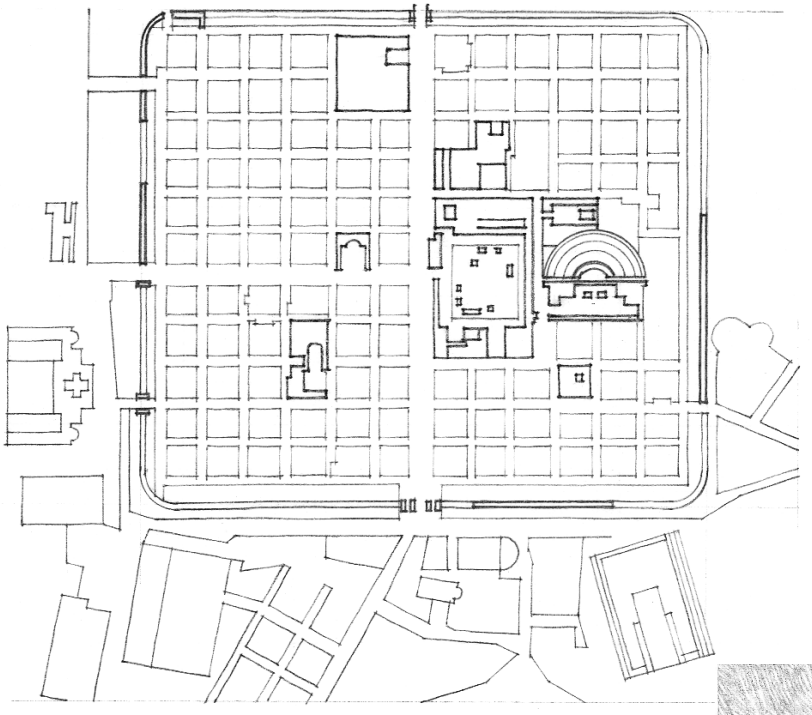
DeVore House (Project), Montgomery County, Pennsylvania, 1954, Louis Kahn



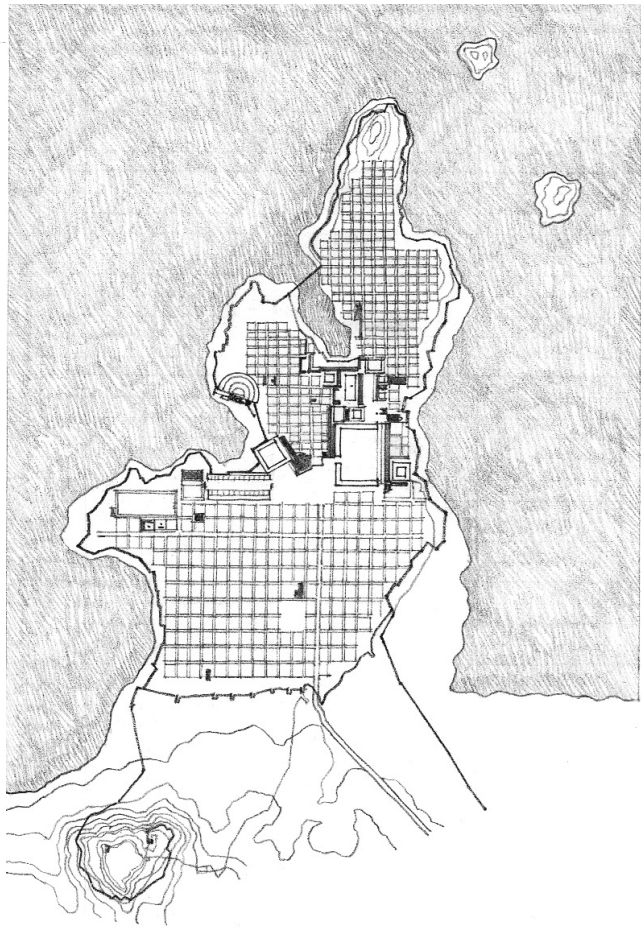
Salvation Army Hostel, Paris, 1928–1933, Le Corbusier



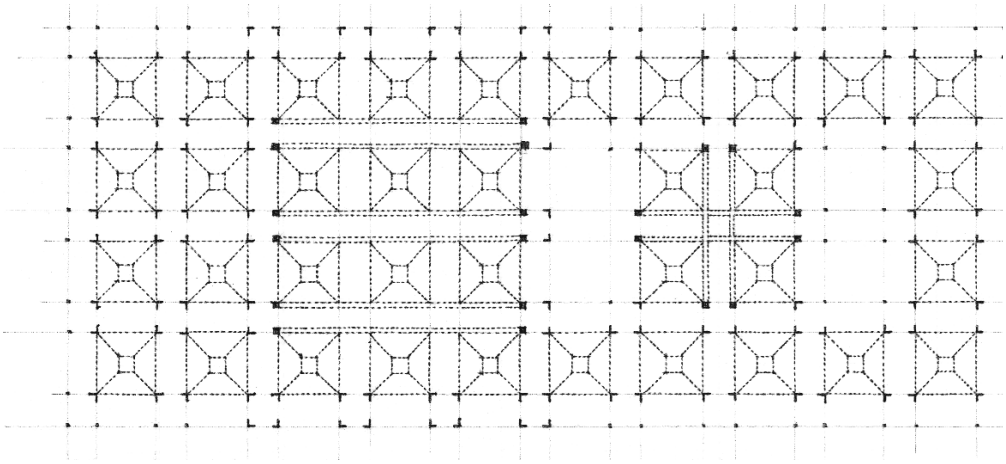
Cultural Center (Competition Entry), Leverkusen, Germany, 1962, Alvar Aalto



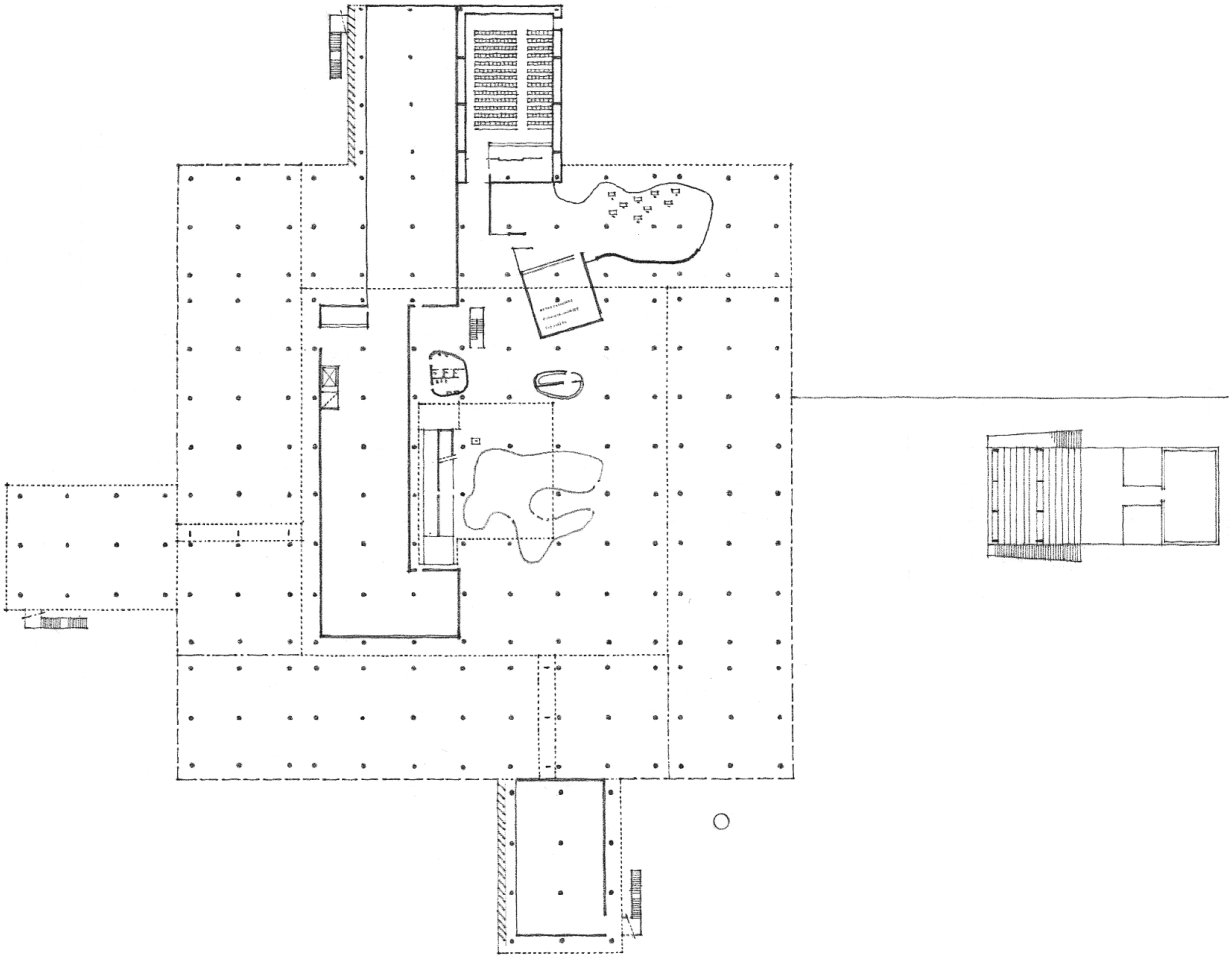
Town Plan of **Timgad**, a Roman colony in North Africa founded 100 B.C.



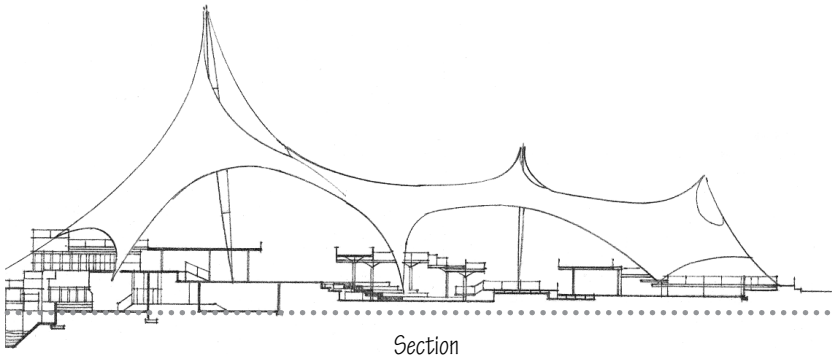
Plan of **Miletus**, 5th century B.C.



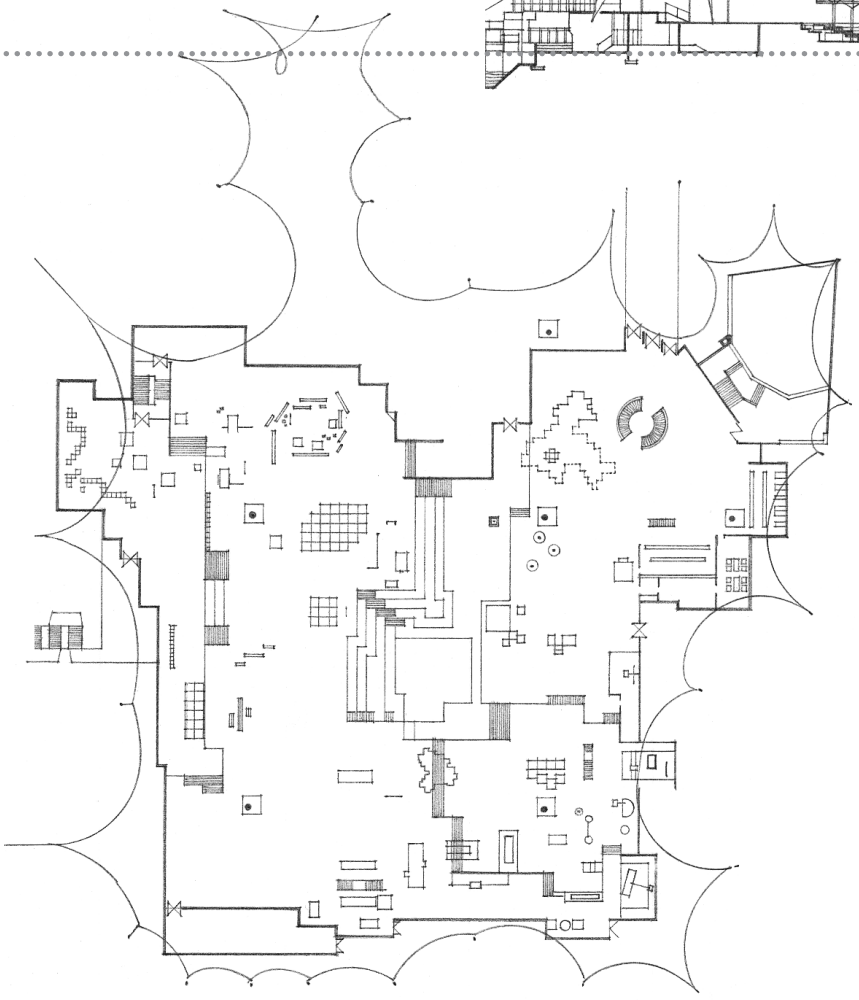
Structural Grid of Main Building, **Jewish Community Center**, Trenton, New Jersey, 1954–1959, Louis Kahn



Museum at Ahmedabad, India, 1954–1957, Le Corbusier

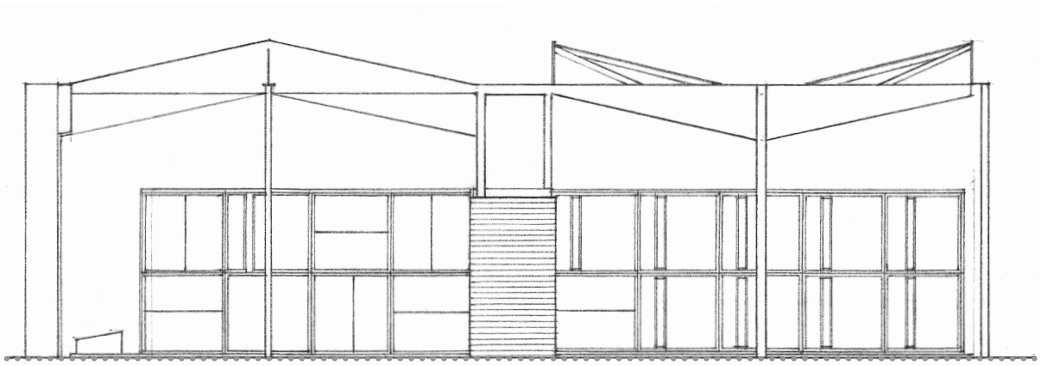


Section

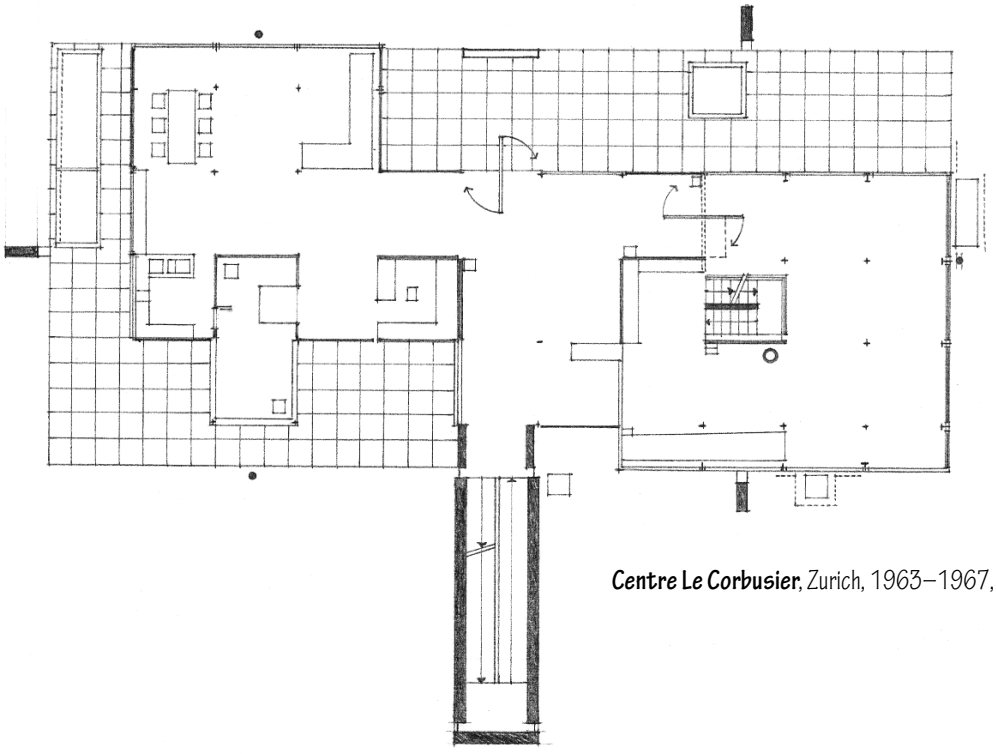


German Pavilion, Montreal World Exposition, 1966–1967, Rolf Gutbrod and Frei Otto

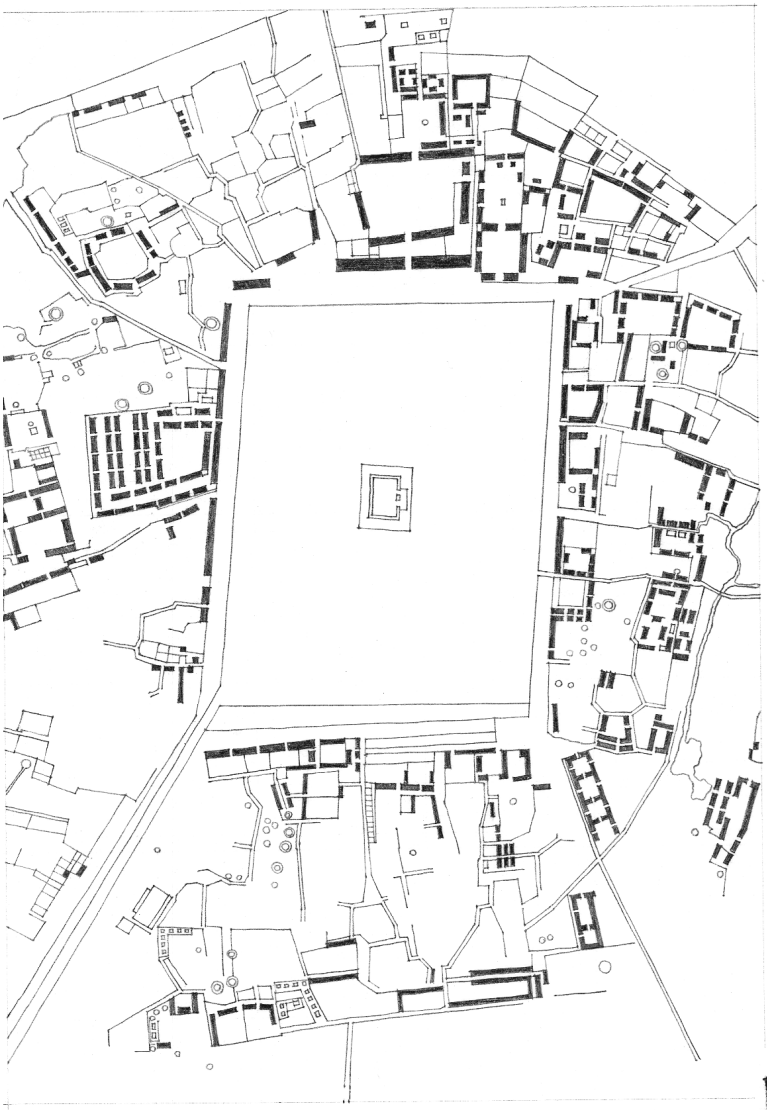
Ground-floor plan



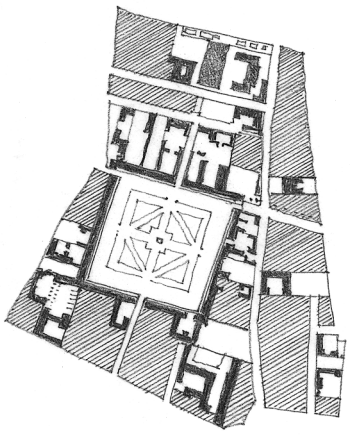
North elevation



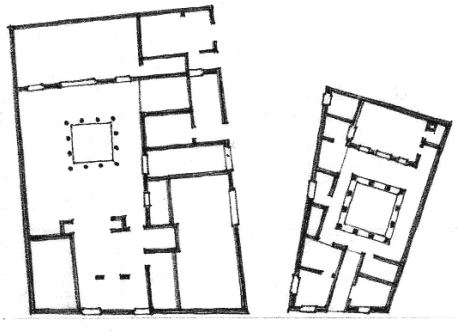
Centre Le Corbusier, Zurich, 1963–1967, Le Corbusier

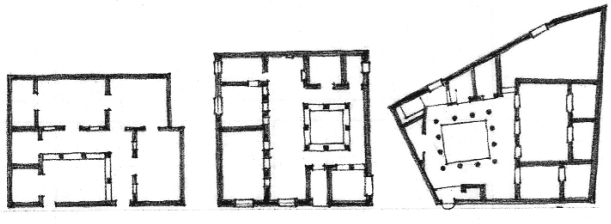


Plan of **Huánuco**, an Inca Town in central Peru

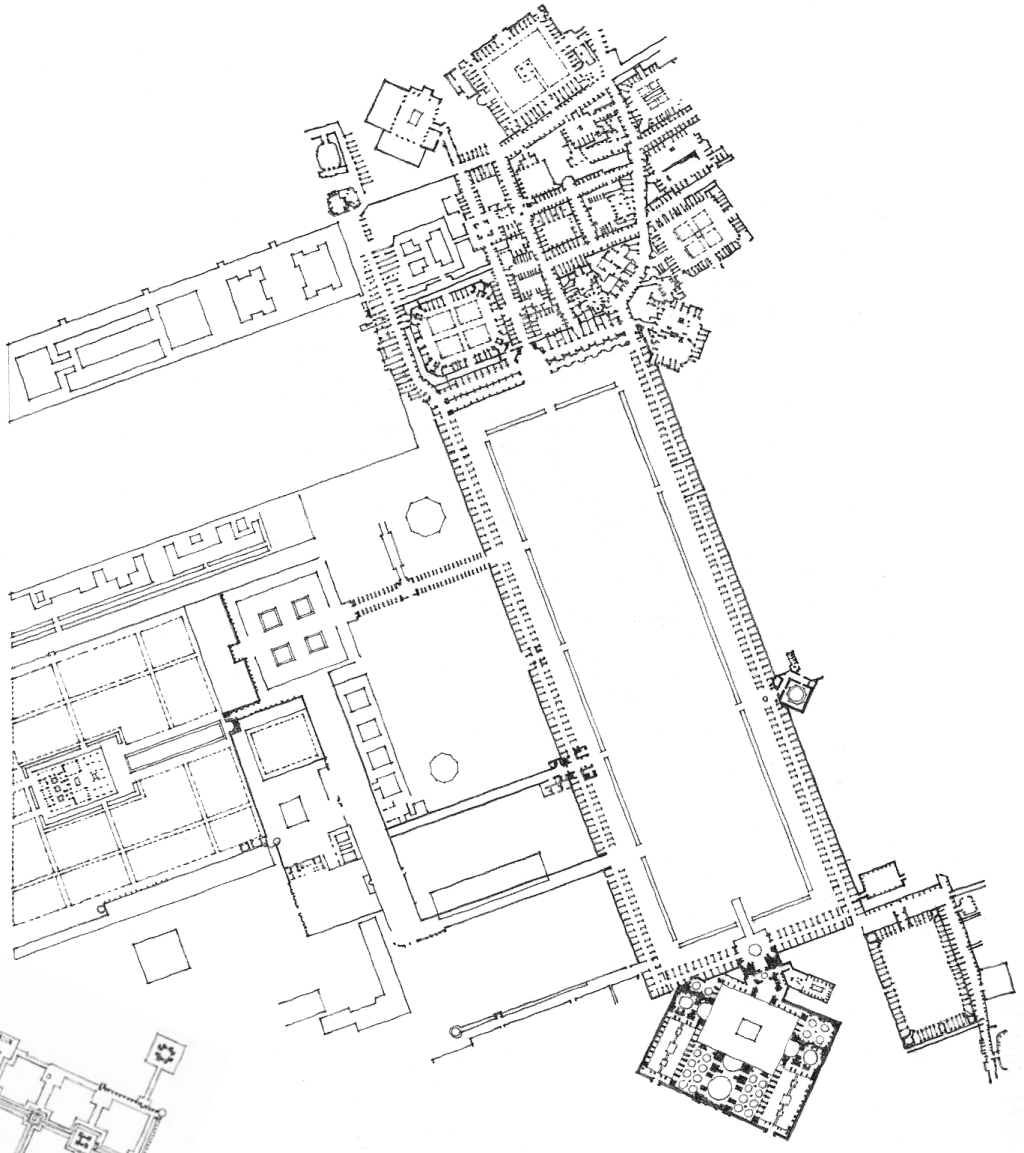


Place Royale, Paris, France, 18th century

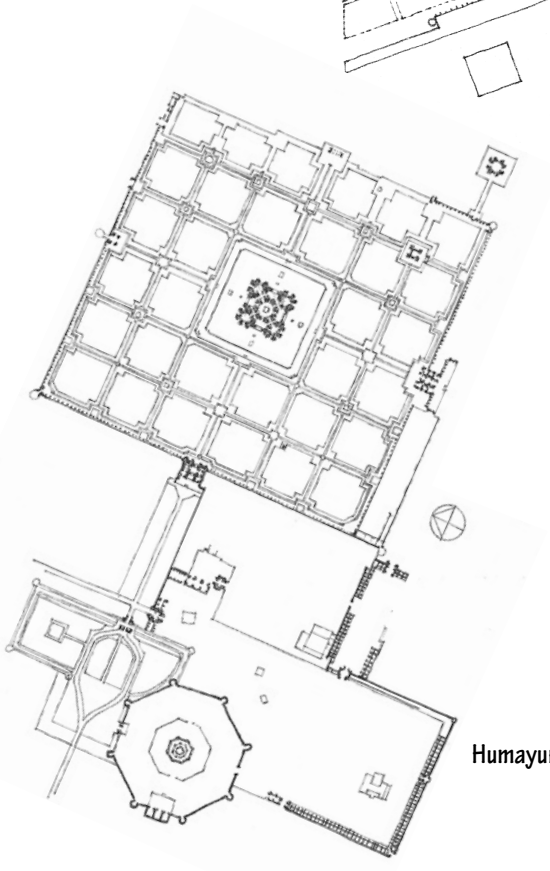




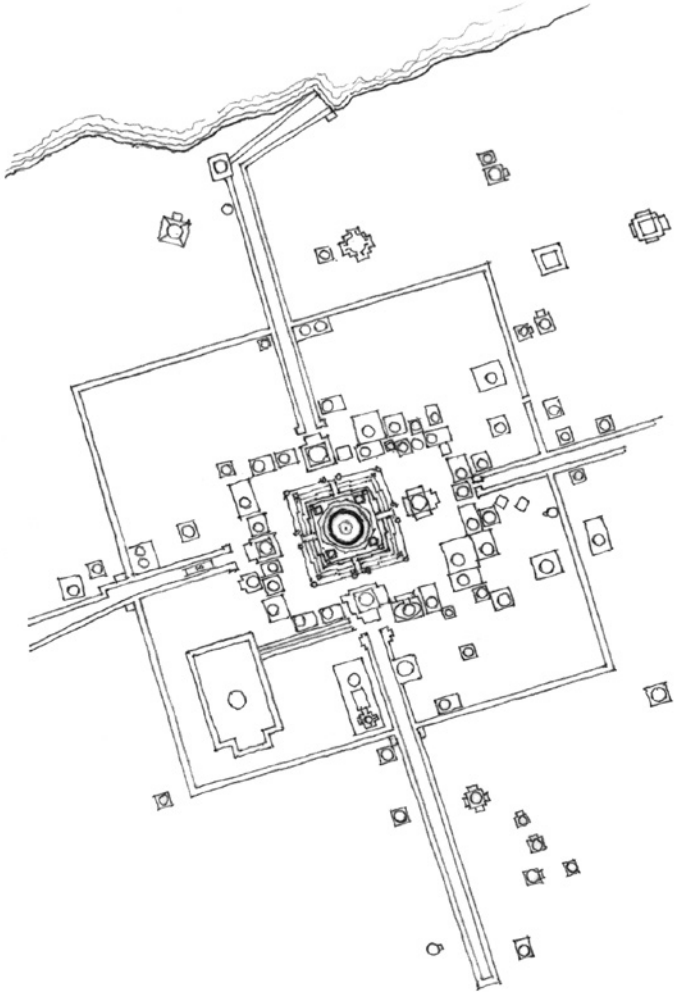
Plan of **Peristyle Courtyard Houses** on Delos, a Greek island in the Aegean



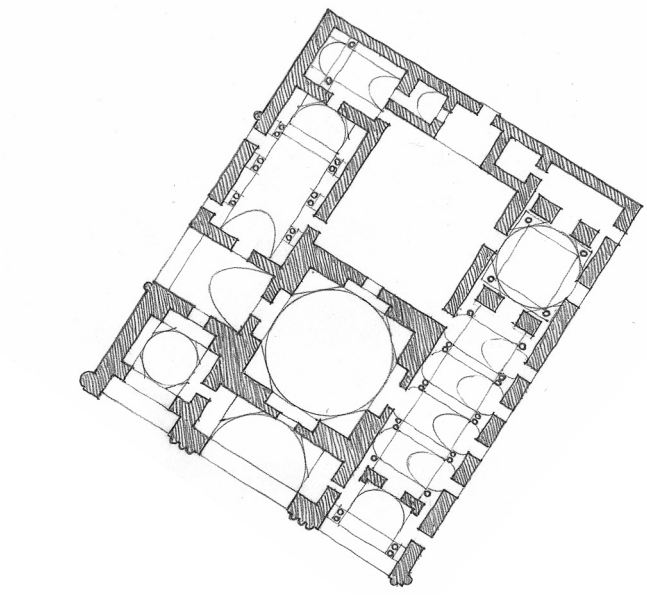
Plan of **Civic Center**, **Isfahan**, *Capital of Persia, 1628*



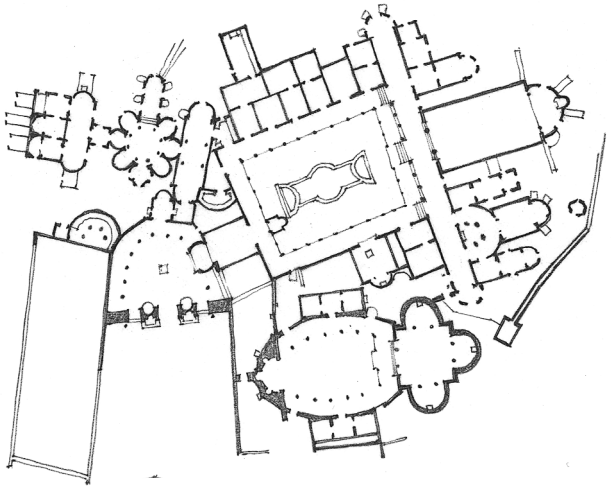
Humayun's Tomb, Delhi, *1570*, Mirak Mirza *Ghiyas*



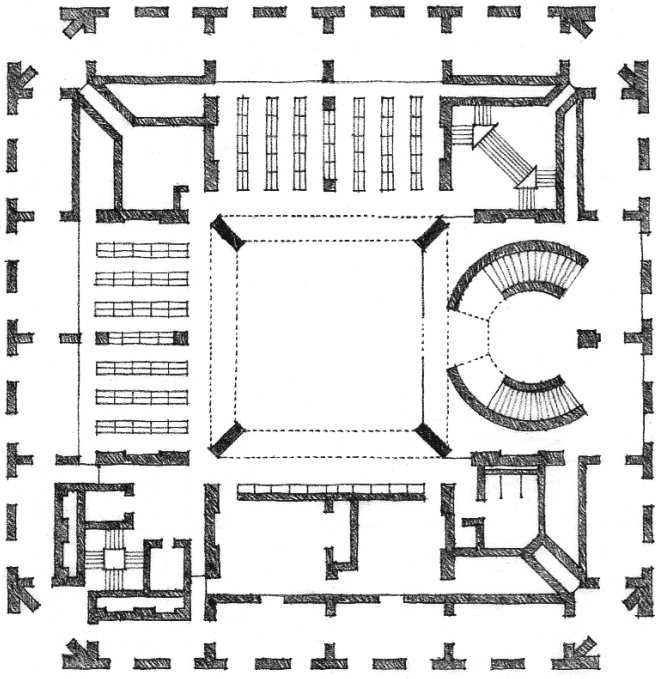
Site plan of **Shwezigon Pagoda**, Bagan, Myanmar, 12th century



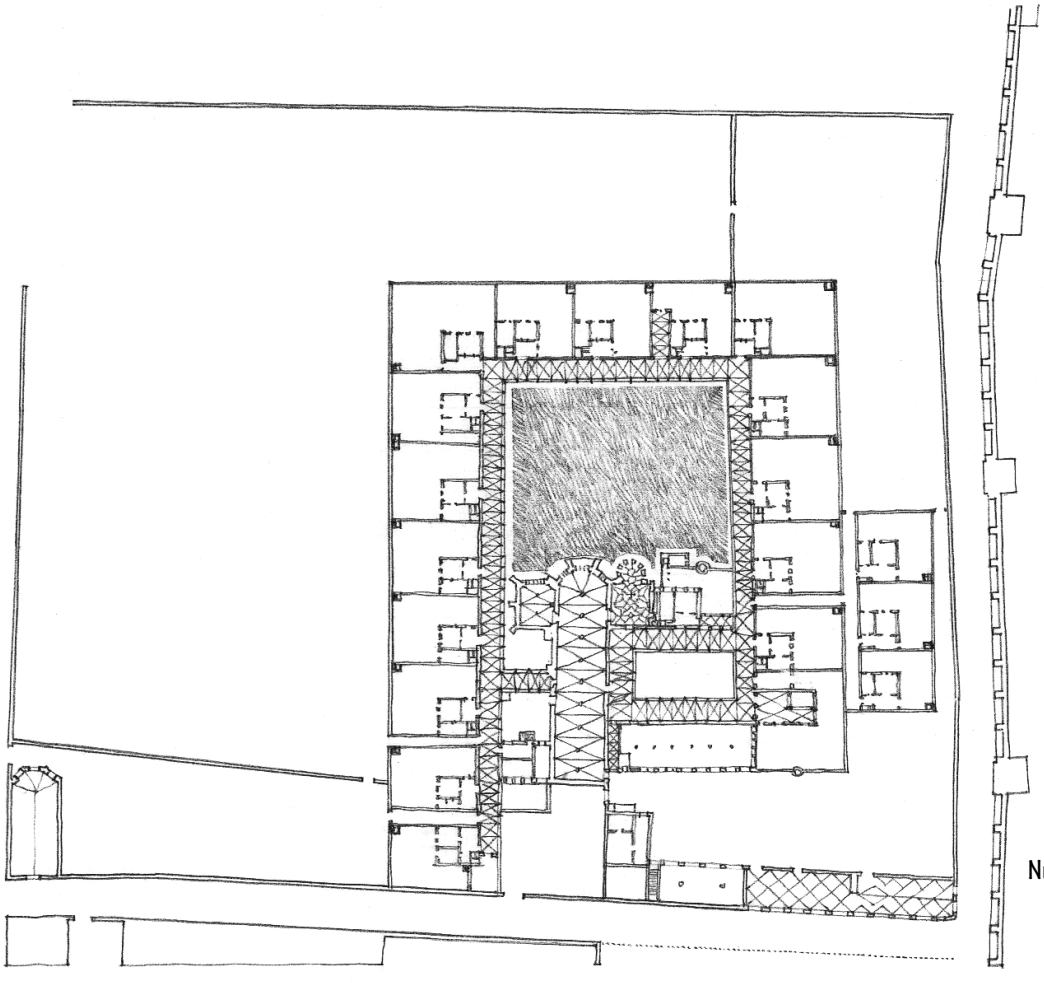
Fire Temple at Sarvistan, Iran, 5th–8th century



Villa Romana del Casale, Piazza Armerina, Sicily, Italy, early 4th century

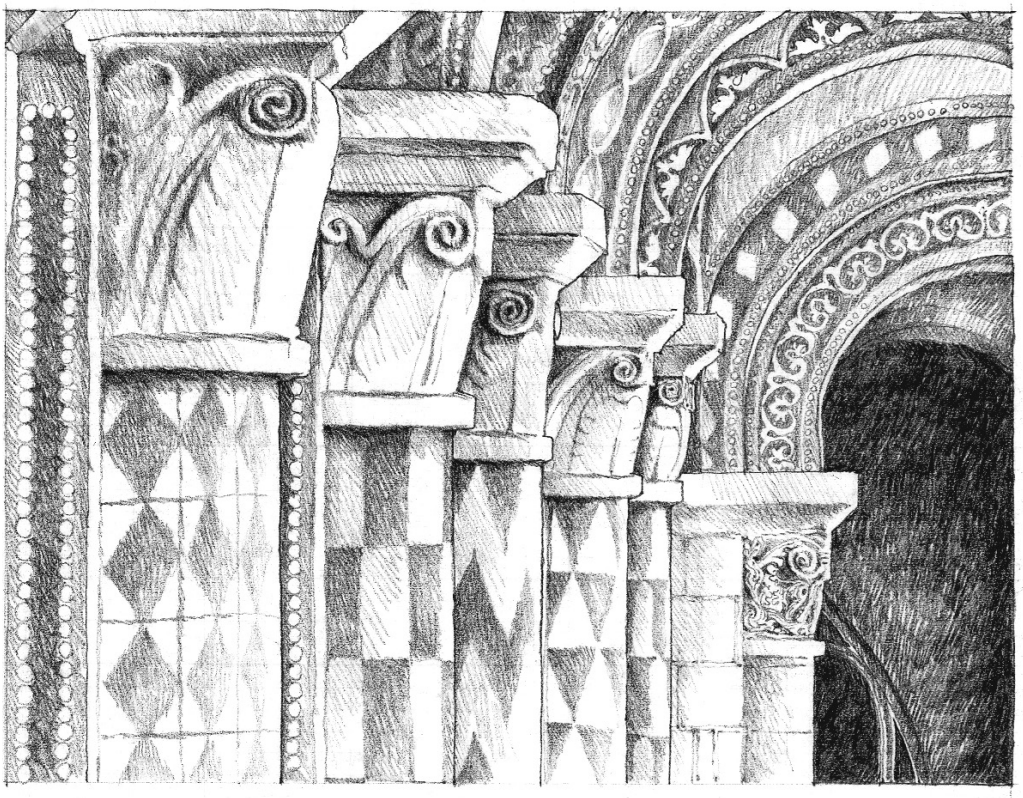


Philip Exeter Academy Library, Exeter, New Hampshire, 1967–1972, Louis Kahn



Nuremberg Charterhouse, 1383

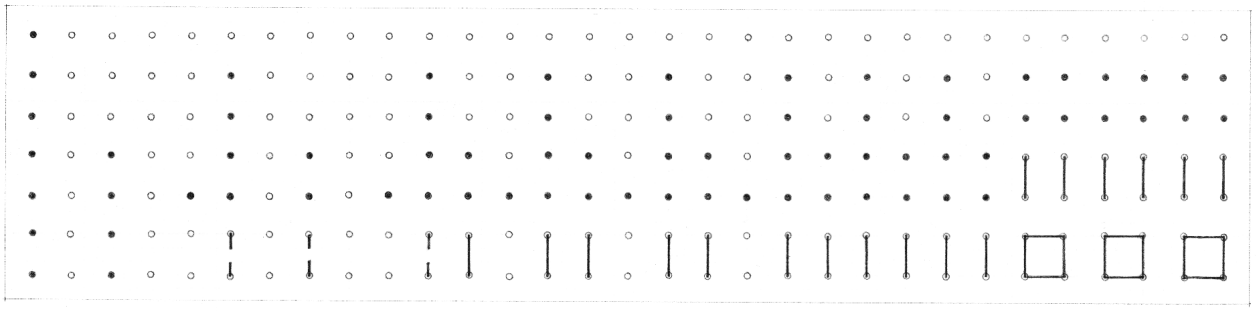
RHYTHM



Column Details, **Notre Dame la Grande**, Poitiers, France, 1130–1145

Rhythm refers to any movement characterized by a patterned recurrence of elements or motifs at regular or irregular intervals. The movement may be of our eyes as we follow recurring elements in a composition, or of our bodies as we advance through a sequence of spaces. In either case, rhythm incorporates the fundamental notion of repetition as a device to organize forms and spaces in architecture.

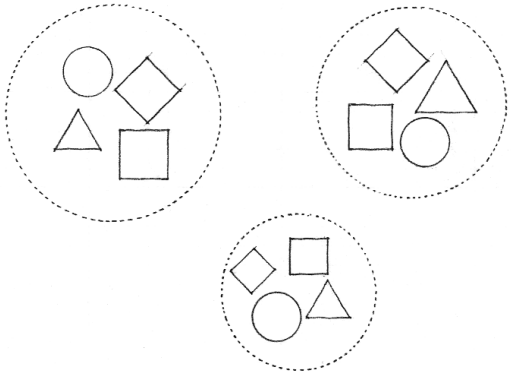
Almost all building types incorporate elements that are by their nature repetitive. Beams and columns repeat themselves to form repetitive structural bays and modules of space. Windows and doors repeatedly puncture the surfaces of a building to allow light, air, views, and people to enter the interior. Spaces often recur to accommodate similar or repetitive functional requirements in the building program. This section discusses the patterns of repetition that can be utilized to organize a series of recurring elements, and the resultant visual rhythms these patterns create.

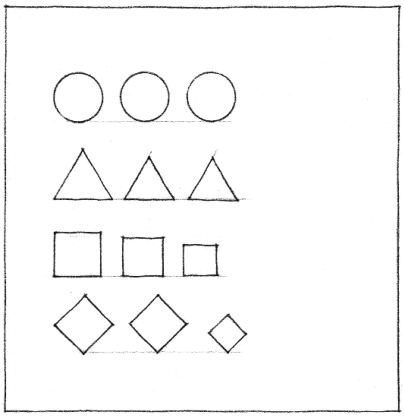


We tend to group elements in a random composition according to:

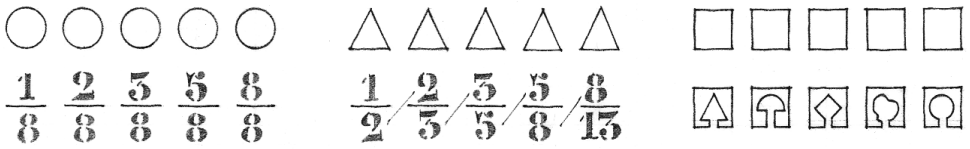
- Their closeness or proximity to one another
- The visual characteristics they share

The principle of repetition utilizes both of these concepts of visual perception to order recurring elements in a composition.

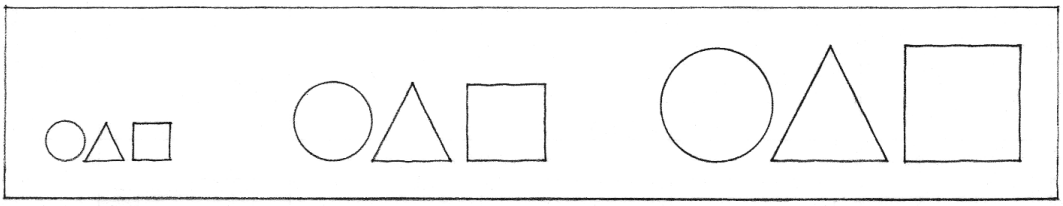




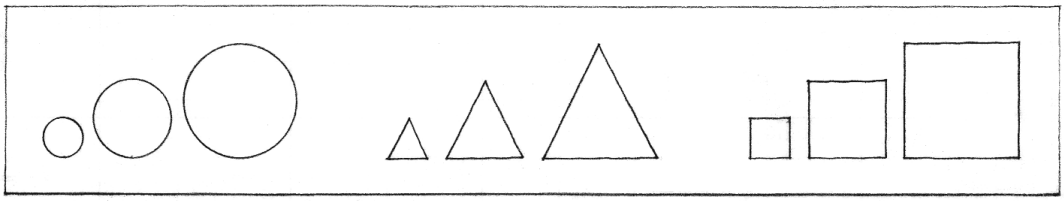
The simplest form of repetition is a linear pattern of redundant elements. Elements need not be perfectly identical, however, to be grouped in a repetitive fashion. They may merely share a common trait or a common denominator, allowing each element to be individually unique, yet belong to the same family.



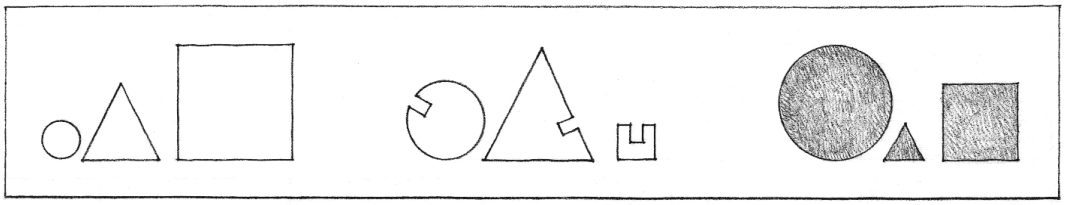
- **Size**



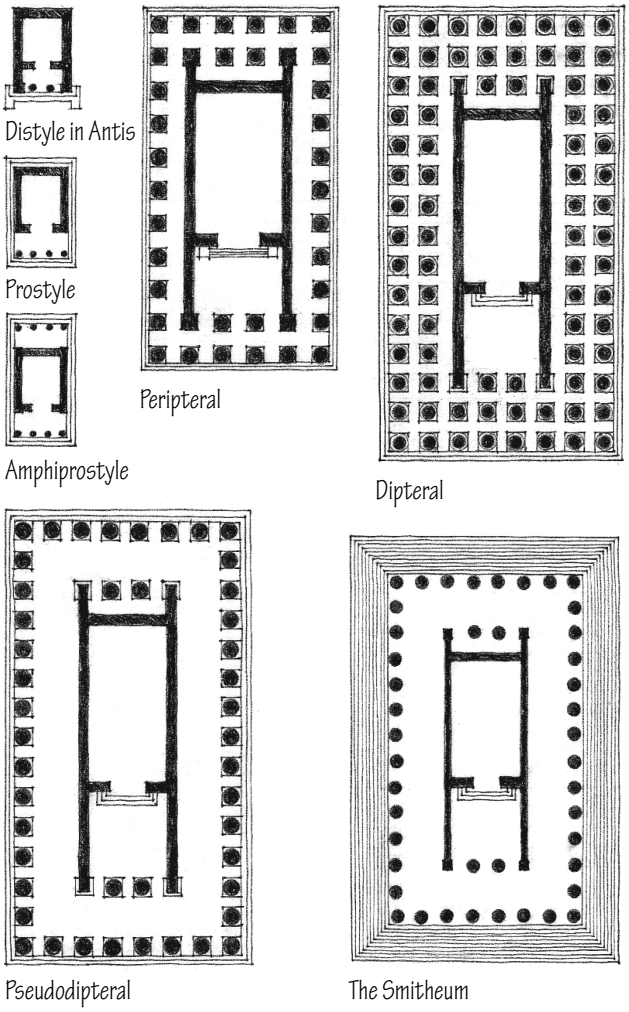
- **Shape**



- **Detail Characteristics**

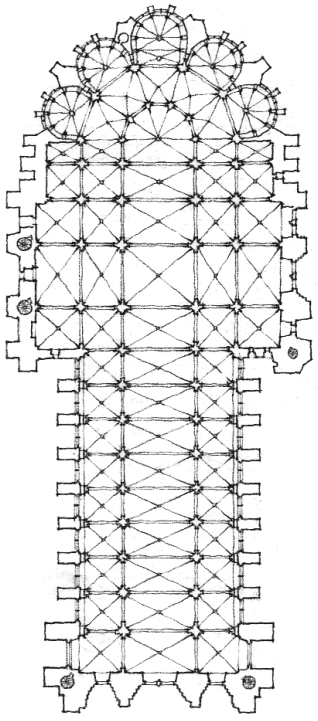


REPETITION

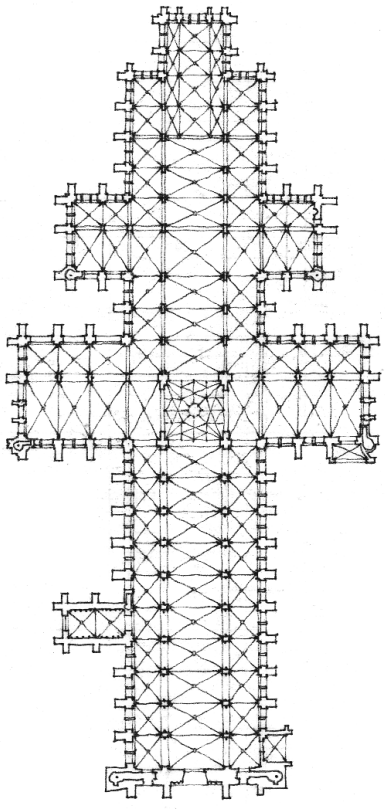


Classification of Temples according to the arrangements of the colonnades. From Book III, Chapter II of Vitruvius' *Ten Books on Architecture.*

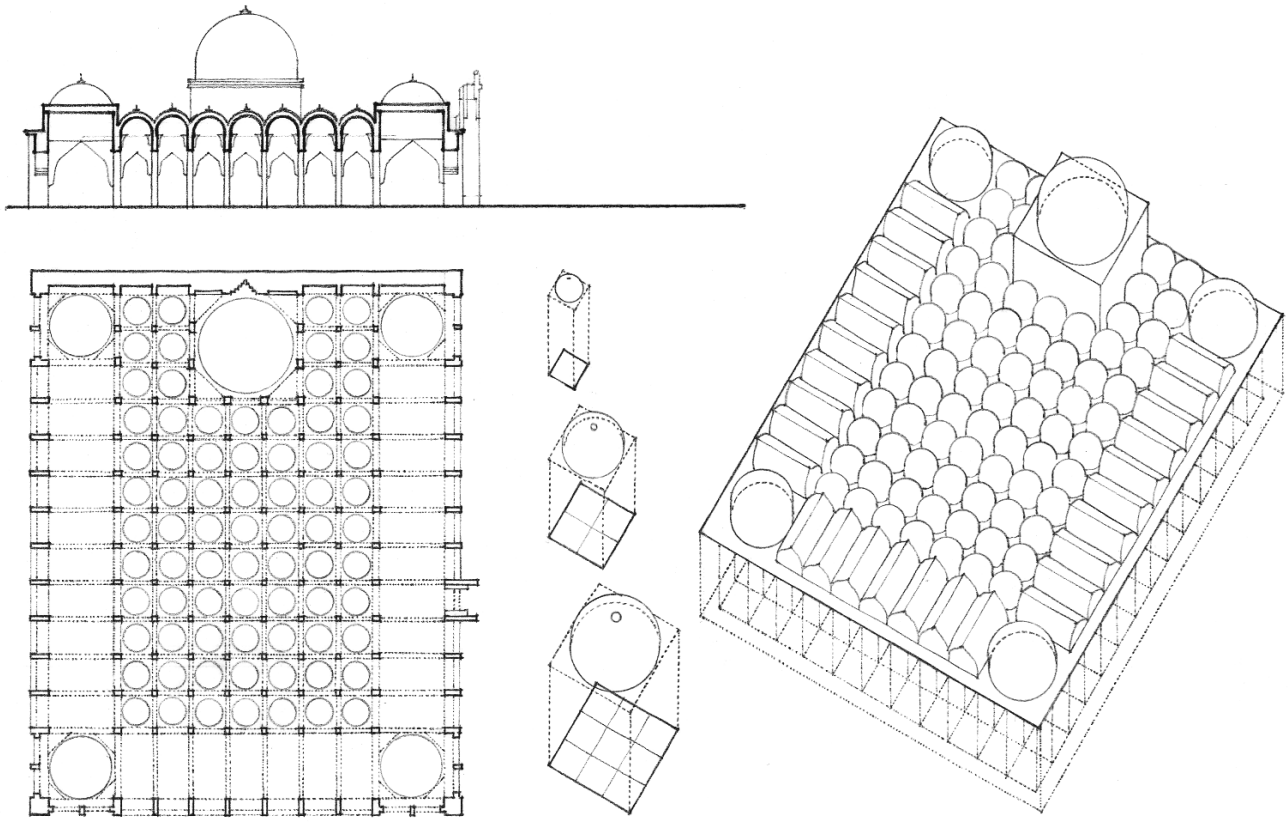
Structural patterns often incorporate the repetition of vertical supports at regular or harmonious intervals that define modular bays or divisions of space. Within such repetitive patterns, the importance of a space can be emphasized by its size and placement.



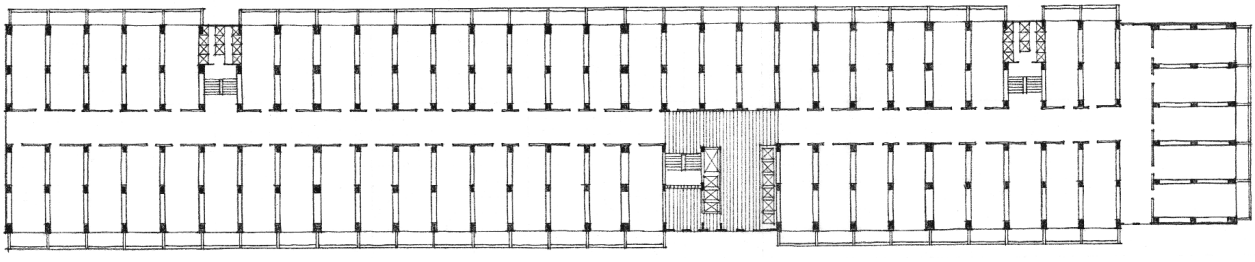
Reims Cathedral, England, 1211–1290



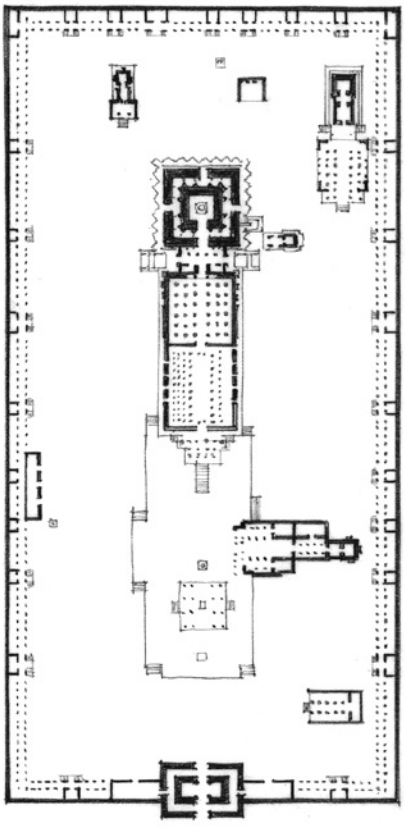
Salisbury Cathedral, England, 1220–1260



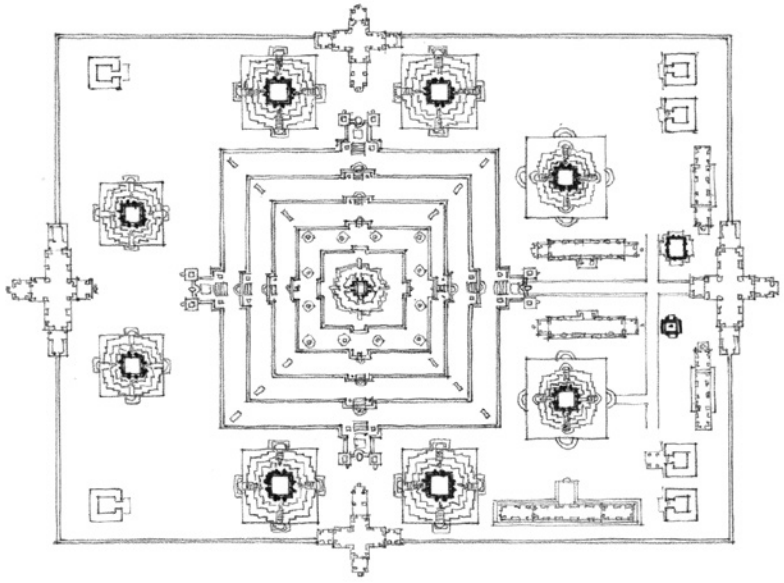
Jami Masjid, *Gulbarga, India, 1367*



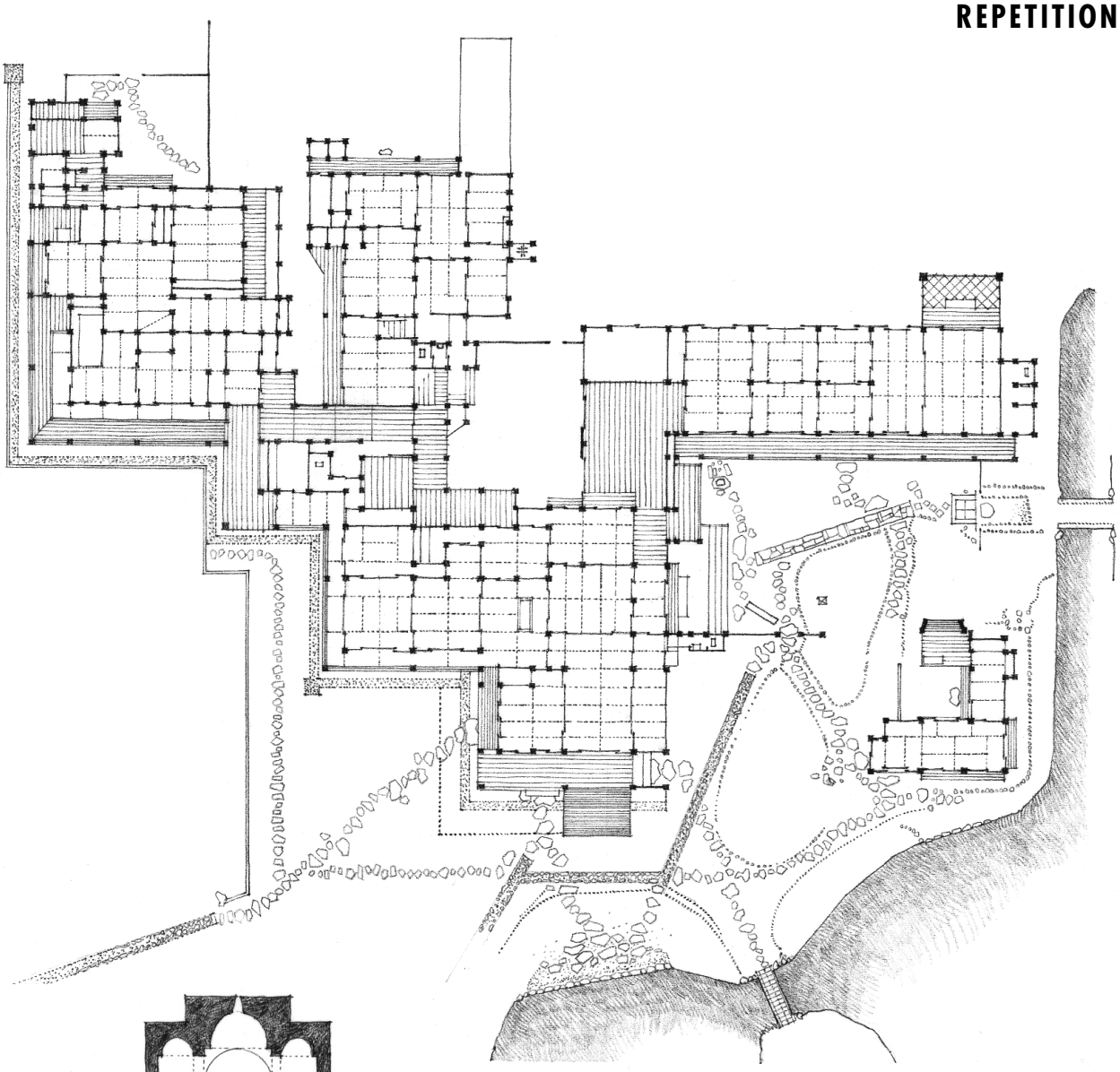
Typical-floor plan, **Unité d'Habitation**, *Marseilles, 1946–1952, Le Corbusier*



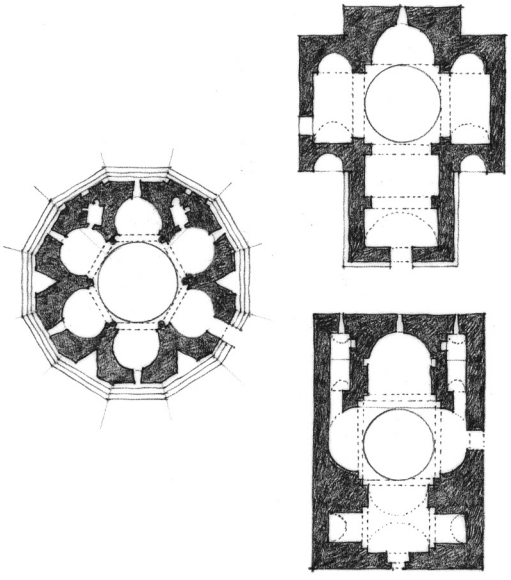
Rajarajeshwara Temple, Thanjavur, India, 11th century



Bakong Temple, near Siem Reap, Cambodia, c. A.D. 881

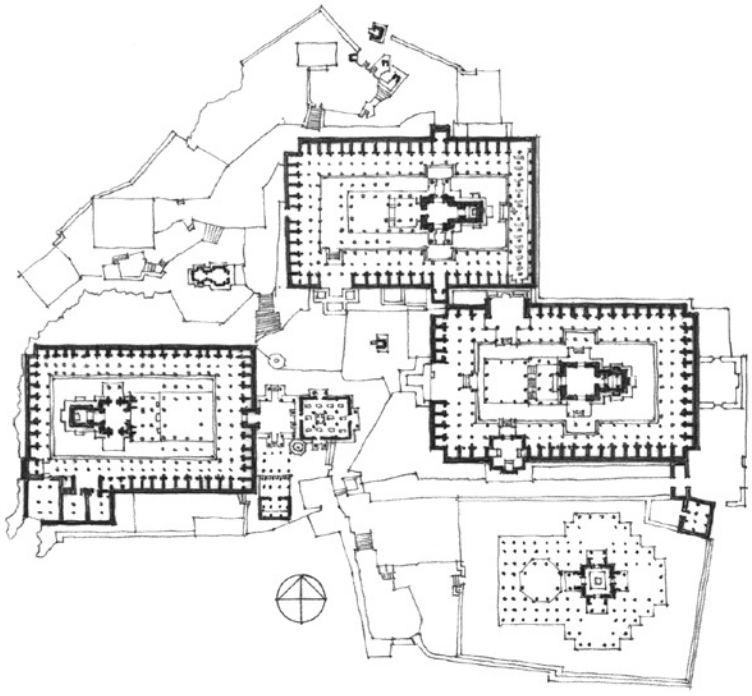


Katsura Imperial Villa, Kyoto, Japan, 17th century

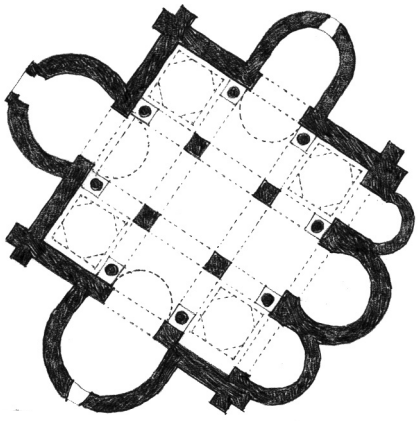


Typology of 6th-century Armenian churches

REPETITION

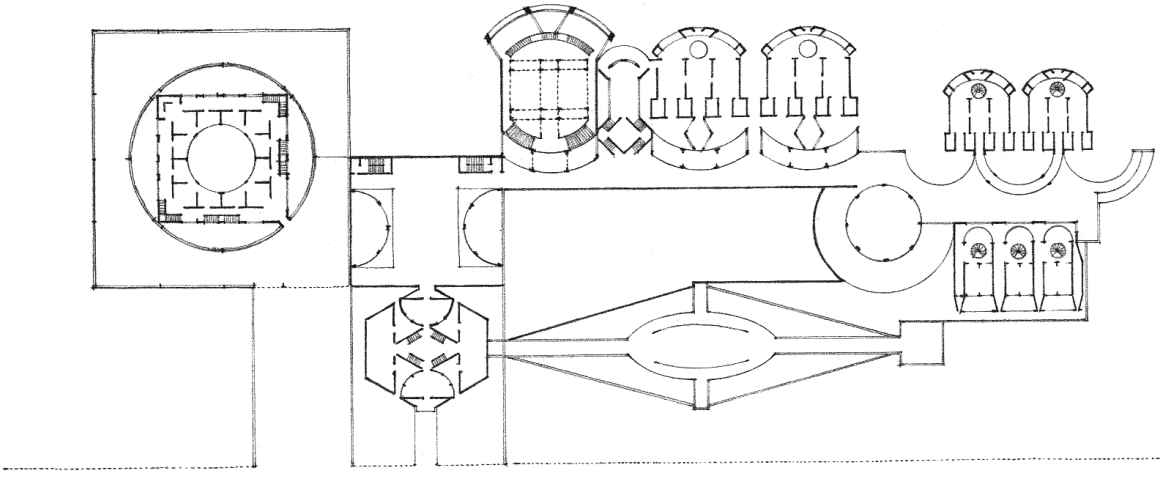


Dilwara Jain Temples, Mt. Abu, India, 11th–16th centuries

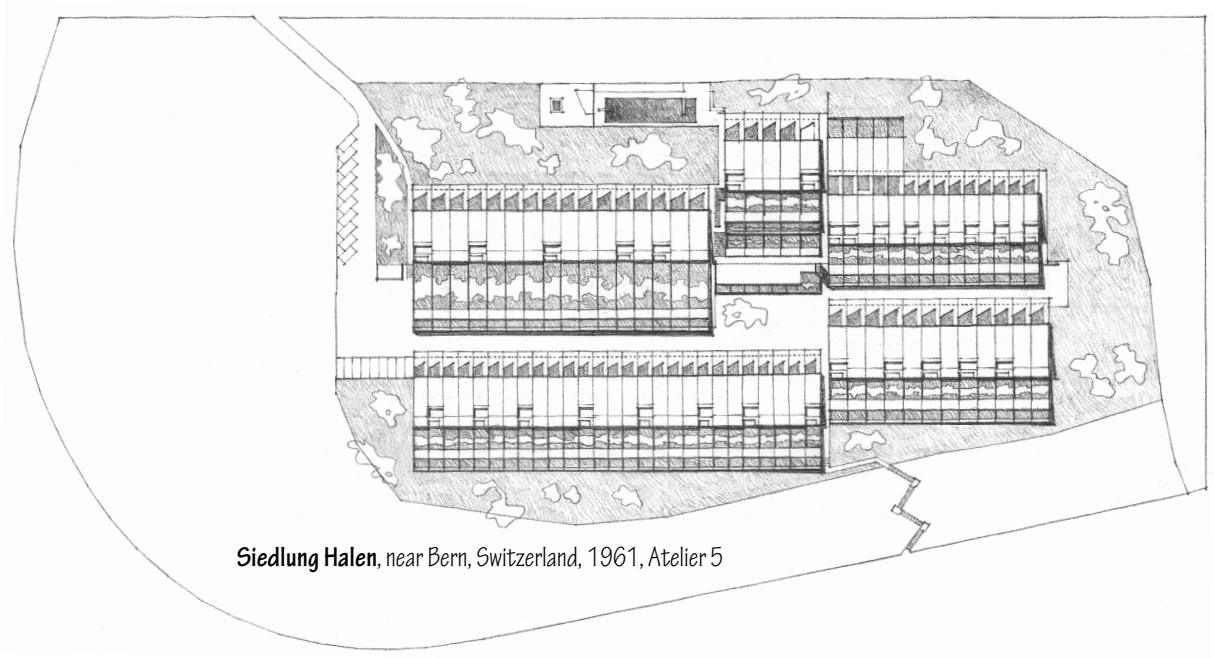


Germigny-des-Prés, France, A.D. 806–811, Oton Matsaetsi

As in music, a rhythmic pattern may be legato, continuous, and flowing, or staccato and abrupt in its pace or cadence.



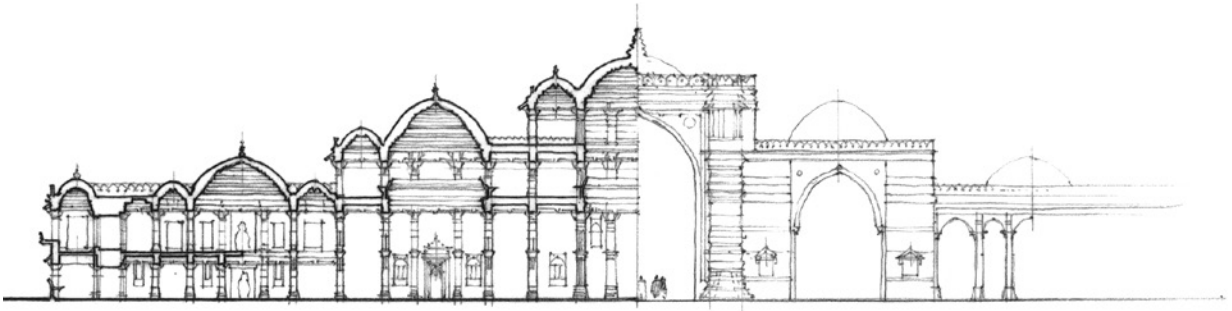
Capitol Complex (Project), Islamabad, Pakistan, 1965, Louis Kahn



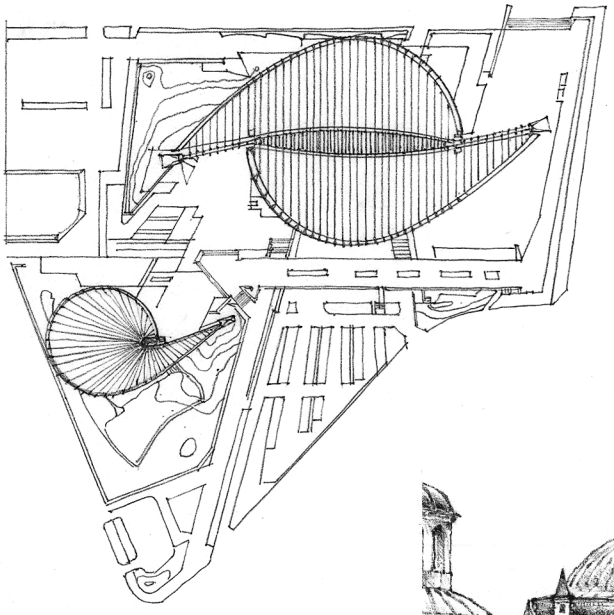
Siedlung Halen, near Bern, Switzerland, 1961, Atelier 5

Residential fabric of 1st-century **Pompeii**

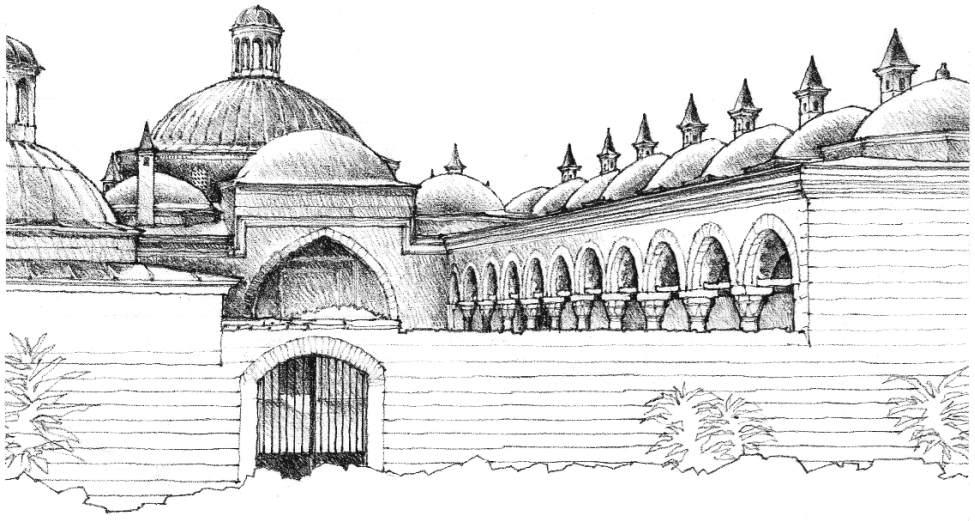
REPETITION



Section through main prayer hall: **Jami Masjid**, Ahmedabad, India, 1423

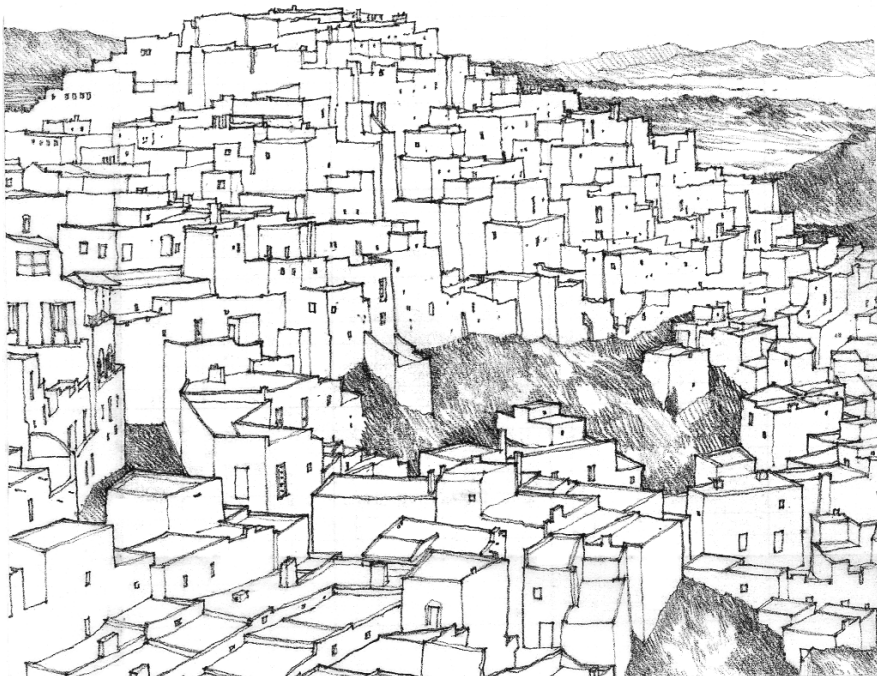


Olympic Arena, Tokyo, Japan, 1961–1964, Kenzo Tange



Rhythmic patterns provide continuity and lead us to anticipate what comes next. Any break in the pattern announces and emphasizes the importance of the interrupting element or interval.

Külliye of Beyazid II, Bursa, Turkey, 1398–1403

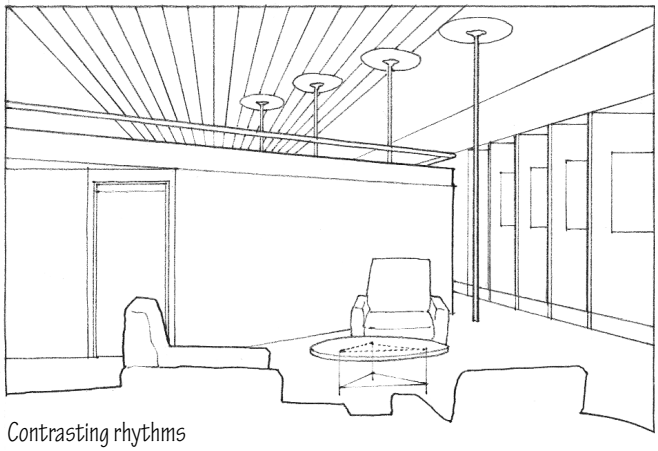


View of Spanish hill town of **Mojácar**

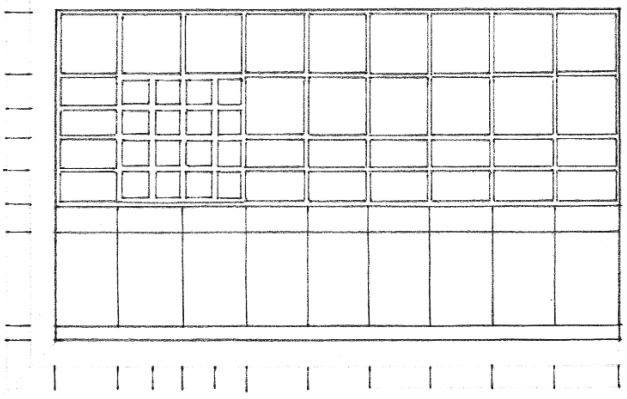
View of **Villa Hermosa**, Spain

REPETITION

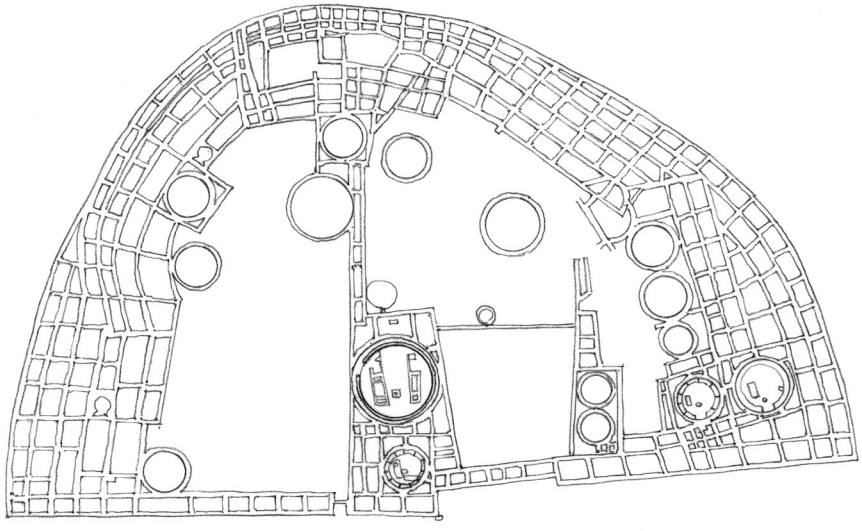
Rhythm created by connecting points in space



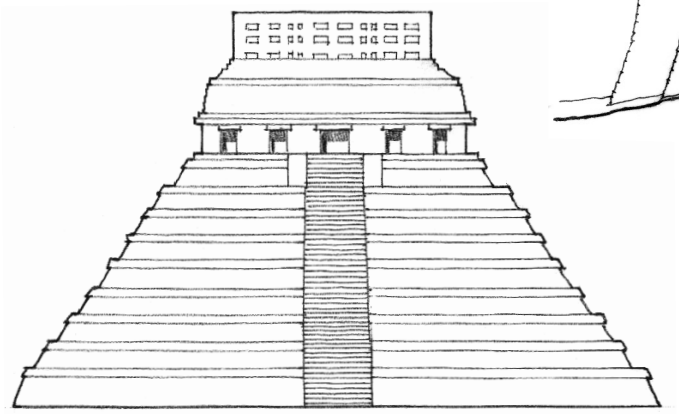
Contrasting rhythms



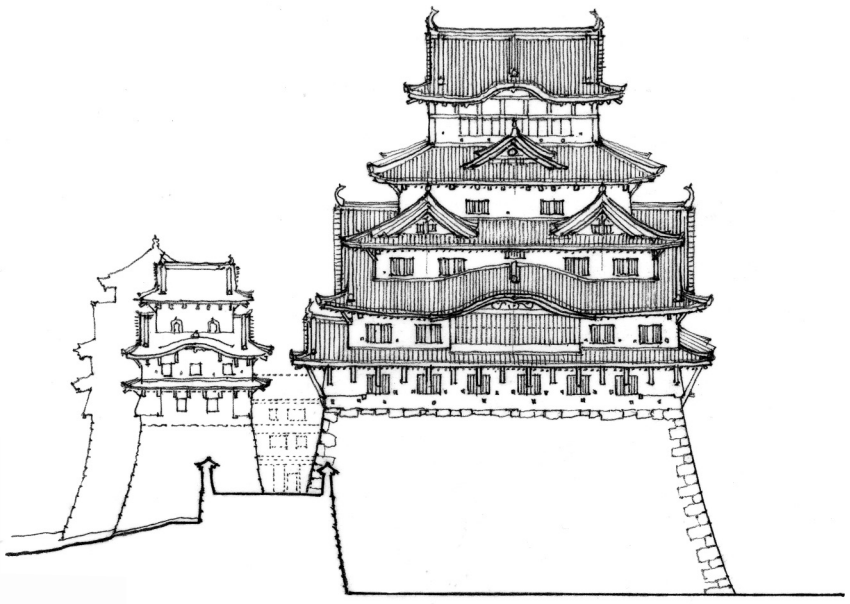
Horizontal and vertical rhythms



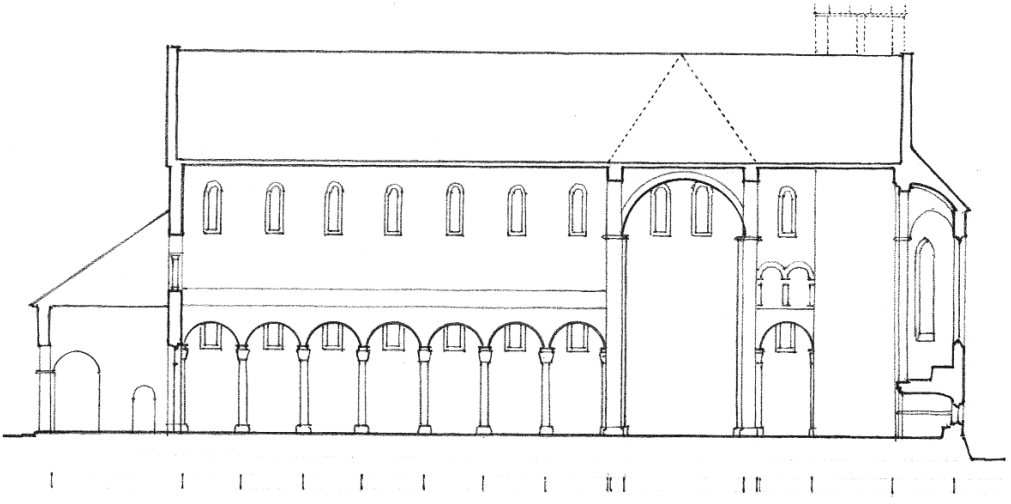
Pueblo Bonito, Chaco Canyon, USA, 10th–13th centuries



Temple of the Inscriptions, Palenque, Mexico, c. A.D. 550



Himeji Castle, Himeji, Japan, begun 1577

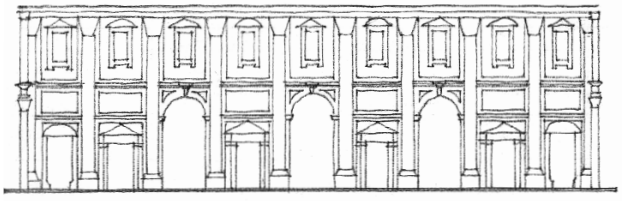


Abbey Church, Alpirsbach, Germany, c. 1000

REPETITION

Victorian Facades fronting a San Francisco street

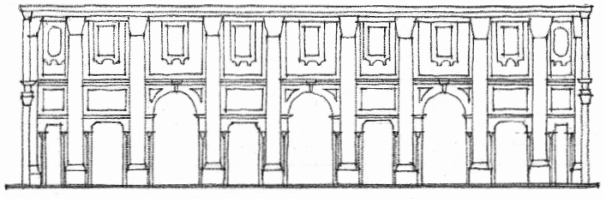
Multiple rhythms can be laid over one another in the facade of a building.



a · b · a · b · a · b · a · b · a . . . . . .

a · a · b · a · b · a · b · a · a . . . . . .

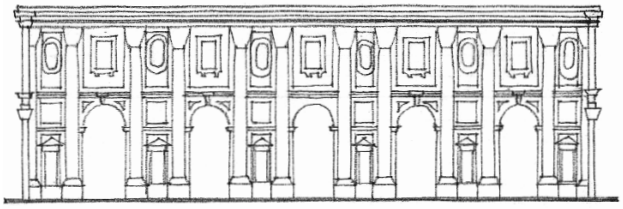
A · B · C · B · C · B · C · B · A . . . . . .



a · b · b · b · b · b · b · b · a . . . . . .

c · a · b · a · b · a · b · a · c . . . . . .

A · B · C · B · C · B · C · B · A . . . . . .

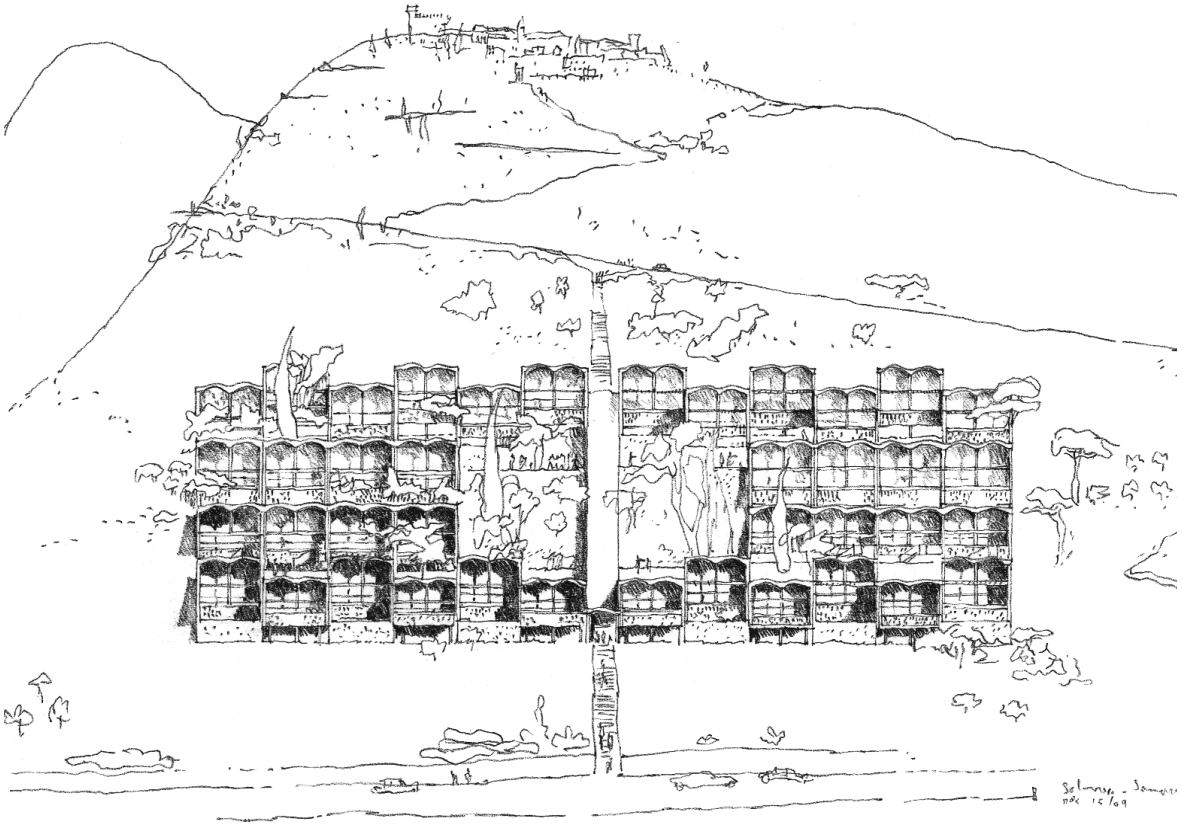


a · b · a · b · a · b · a · b · a · b · a . . . . . .

a · b · a · b · a · b · a · b · a · b · a . . . . . .

A · B · A · B · A · C · A · B · A · B · A . . . . . .

Studies of Internal Facade of a Basilica by Francesco Borromini

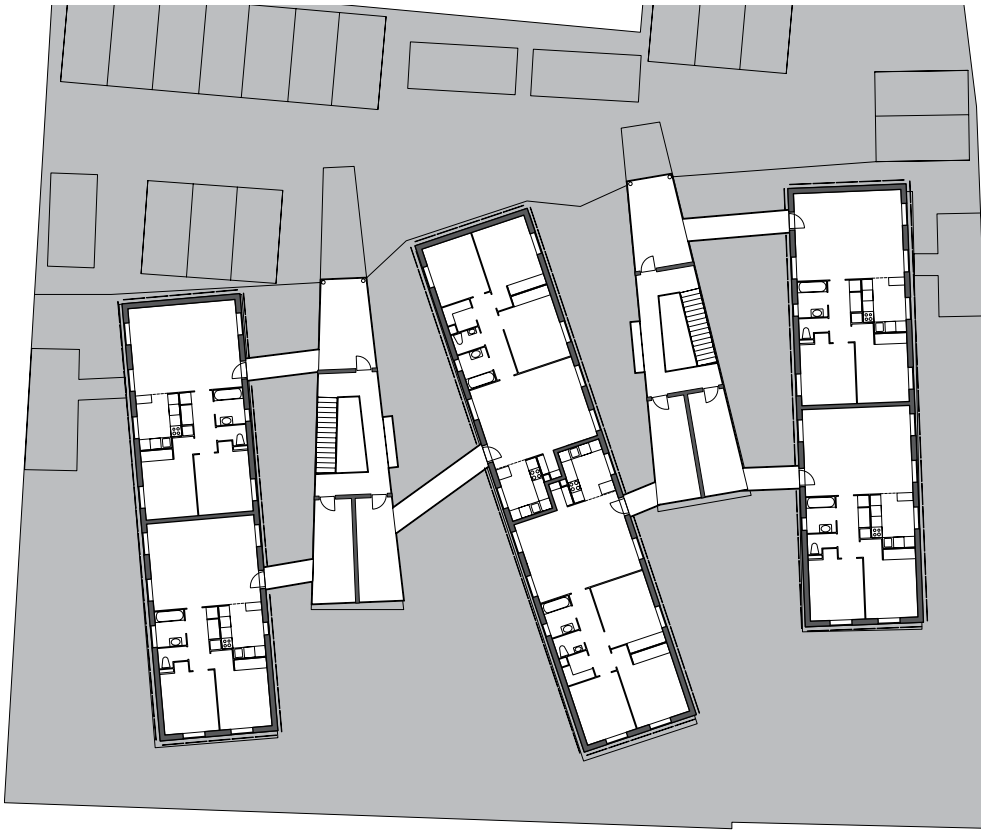


Roq Housing Project, Cap-Martin, on the French Riviera near Nice, 1949, Le Corbusier

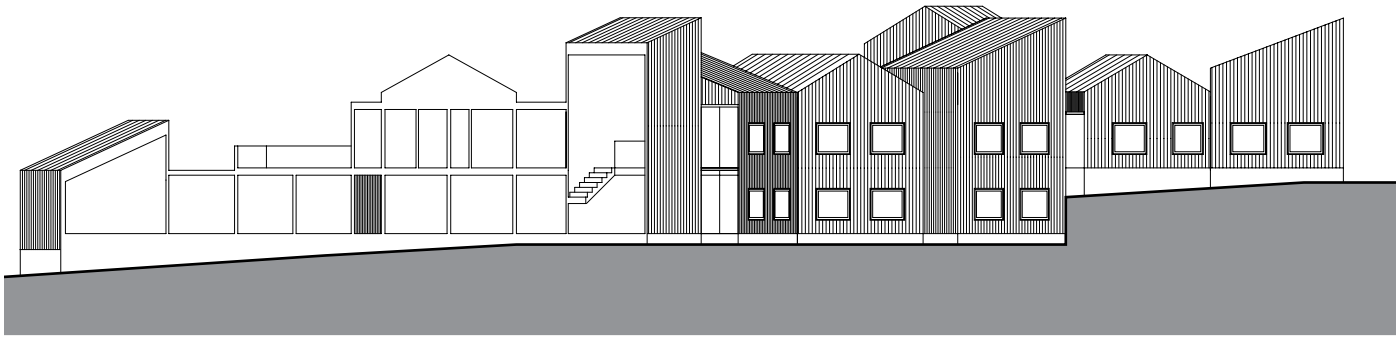
More complex rhythmic patterns can be created by introducing points of emphasis or exceptional intervals into a sequence. These accents or beats help differentiate between the major and minor themes in a composition.

Bedford Park, London, 1875, Maurice Adams, E.W. Goodwin, E.J. May, Norman Shaw

Westendinhelmi Housing, Espoo, Finland, 2001, Marja-Ritta Norri Architects

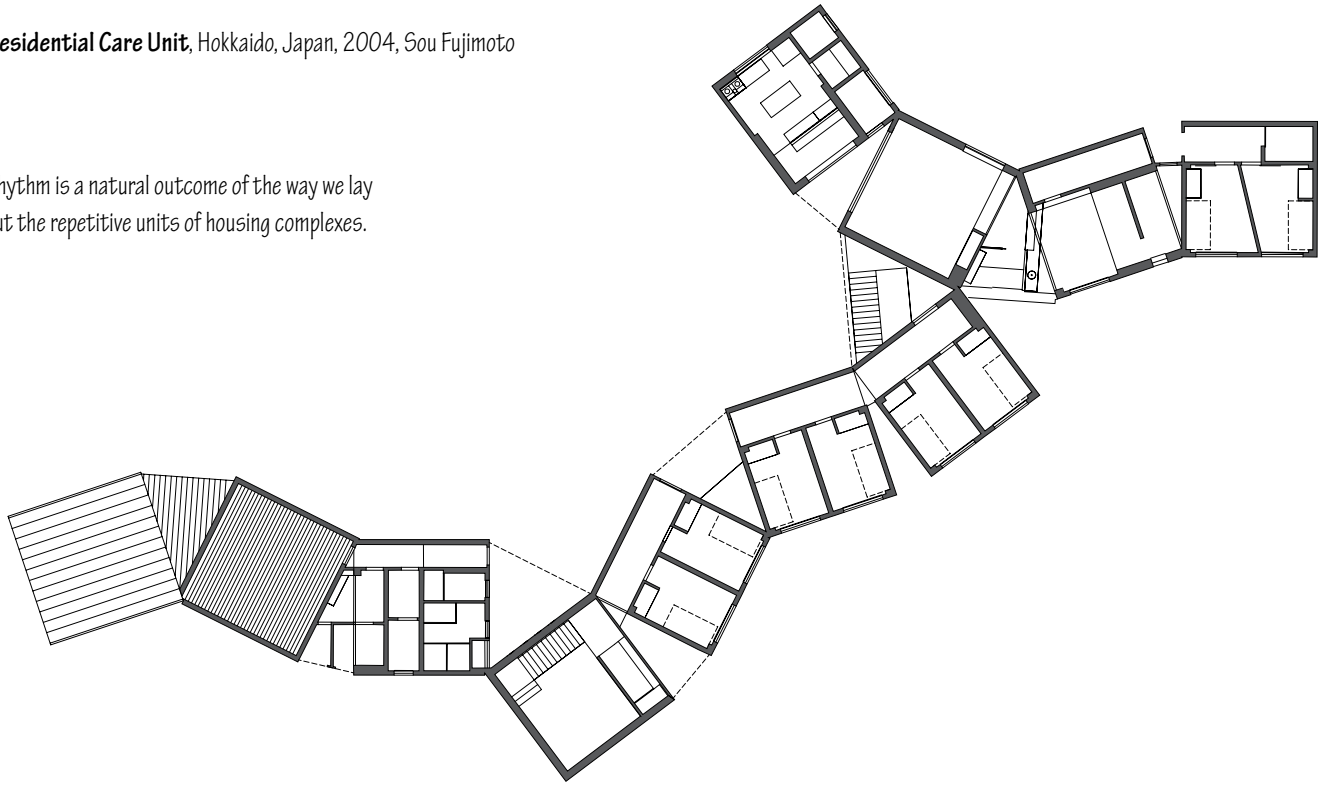


Social Housing, Louviers, France, 2006, Edouard Francois

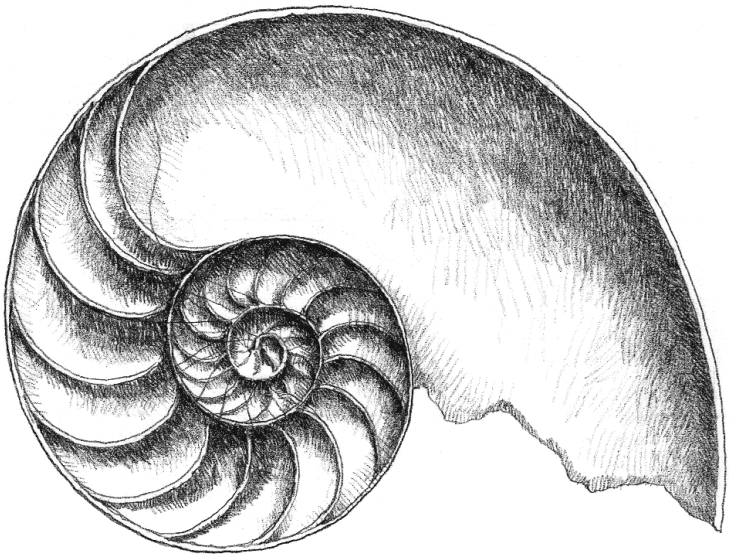


Residential Care Unit, Hokkaido, Japan, 2004, Sou Fujimoto

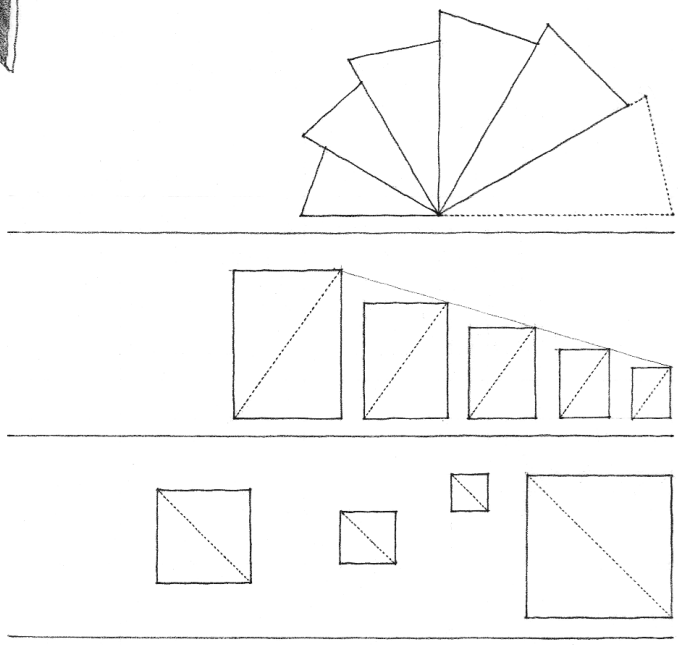
Rhythm is a natural outcome of the way we lay out the repetitive units of housing complexes.



REPETITION

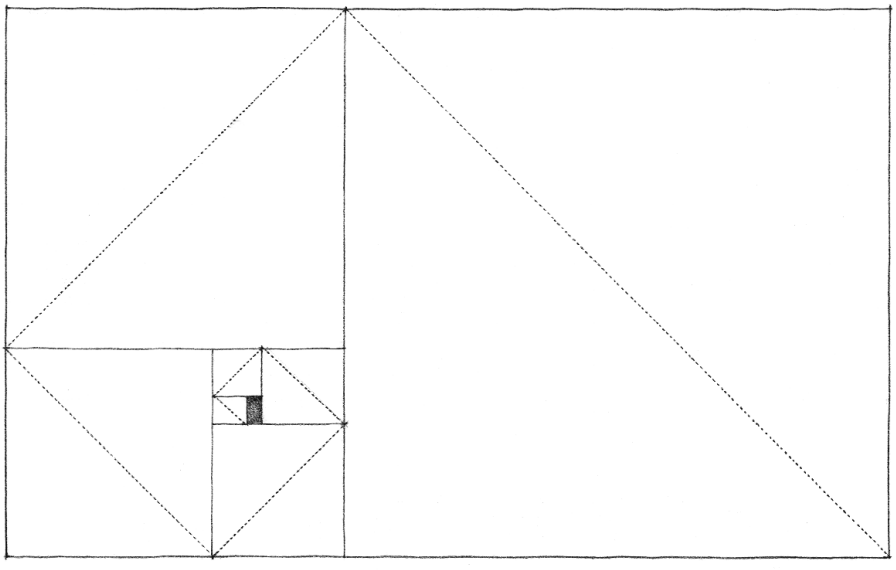


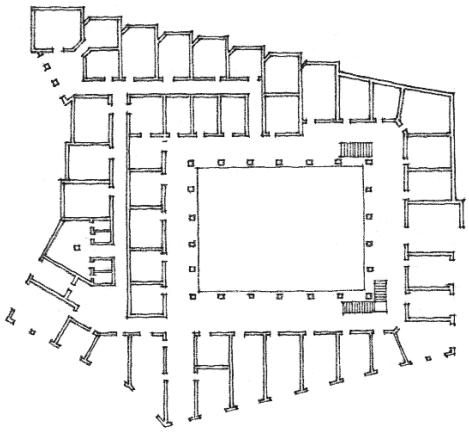
The radial segments of a nautilus shell spiral outward in a reverberating manner from its center and maintain the shell's organic unity through this pattern of additive growth. Using the mathematical ratio of the Golden Section, a series of rectangles can be generated to form a unified organization wherein each rectangle is proportionate to the others as well as to the overall structure. In each of these examples, the principle of reverberation creates a sense of order among a group of elements that are similar in shape but hierarchically graded in size.



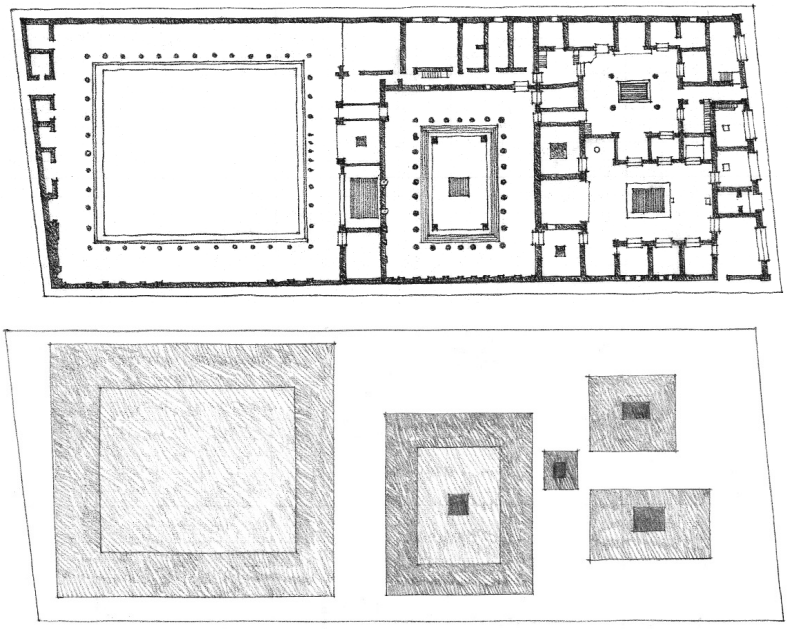
Progressive, reverberating patterns of forms and spaces can be organized in the following ways:

- In a radial or concentric manner about a point
- Sequentially according to size in a linear fashion
- Randomly but related by proximity as well as similarity of form

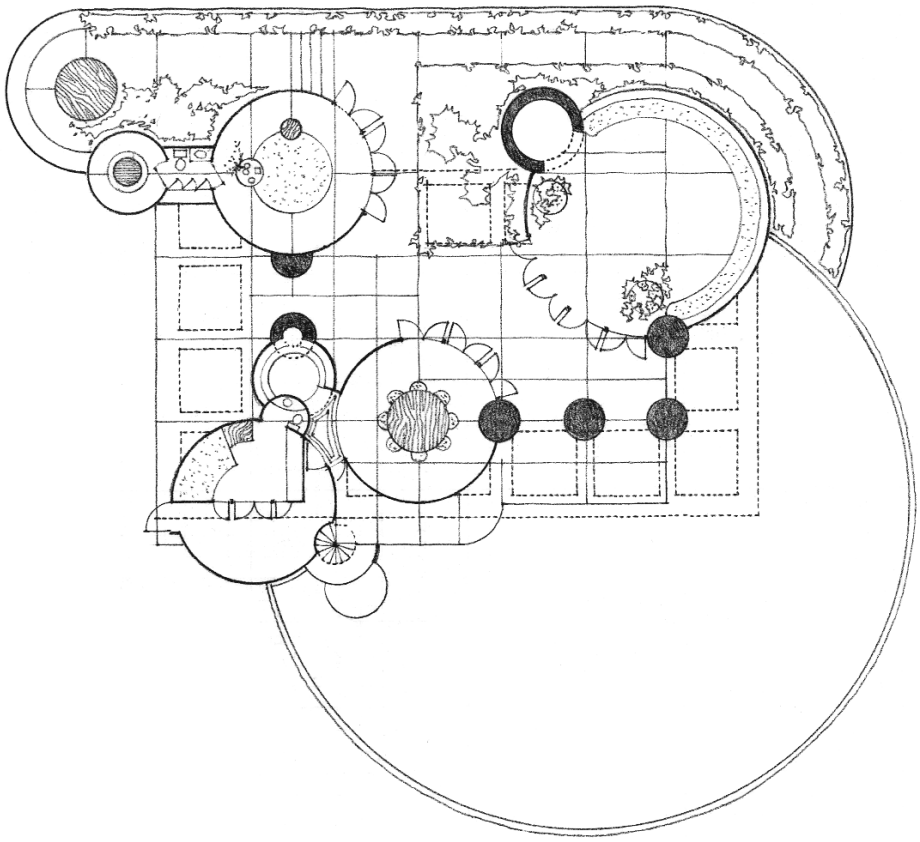




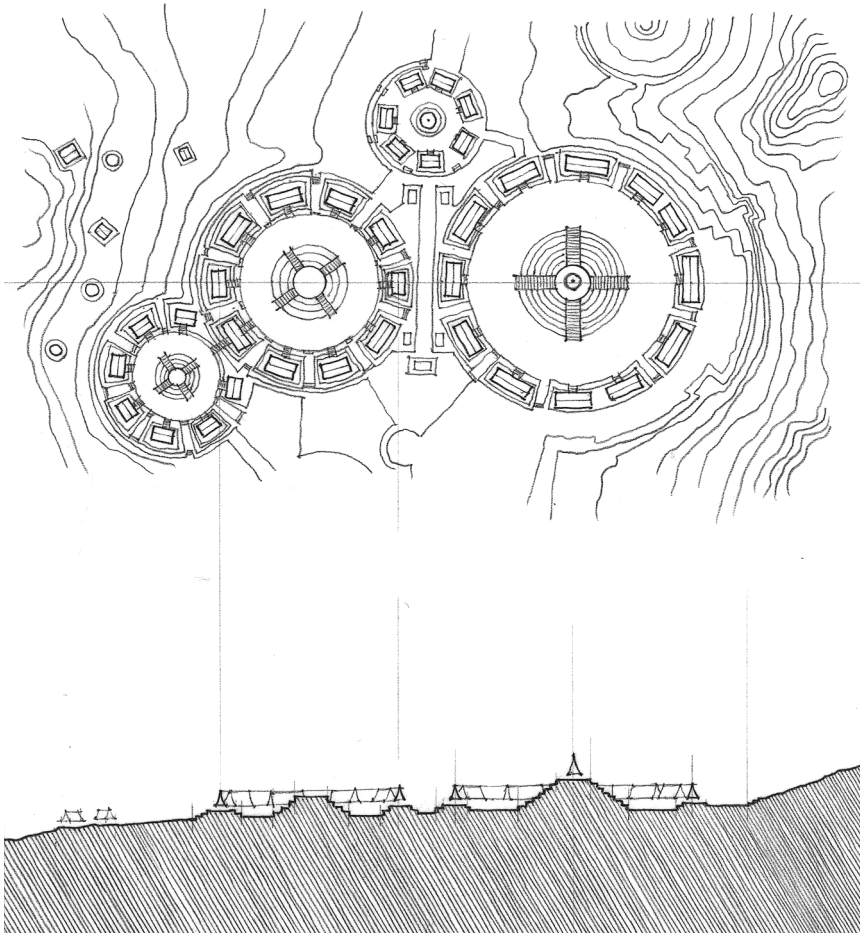
Hasan Pasha Han, Istanbul, 14th century



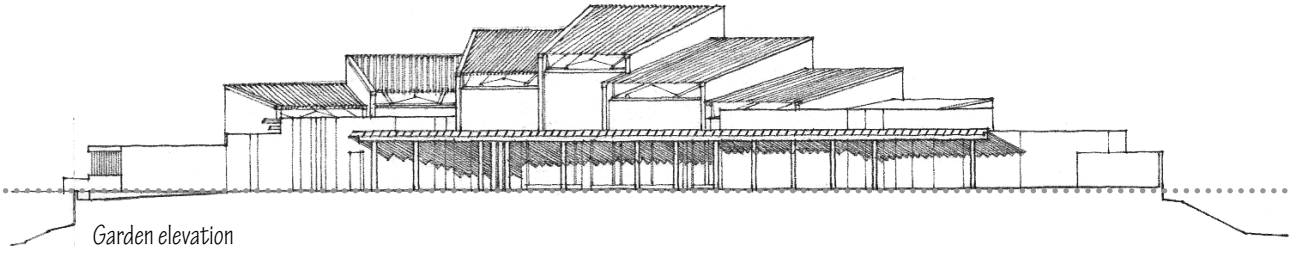
House of the Faun, Pompeii, c. 2nd century B.C.



Jester House (Project), Palos Verdes, California, 1938, Frank Lloyd Wright

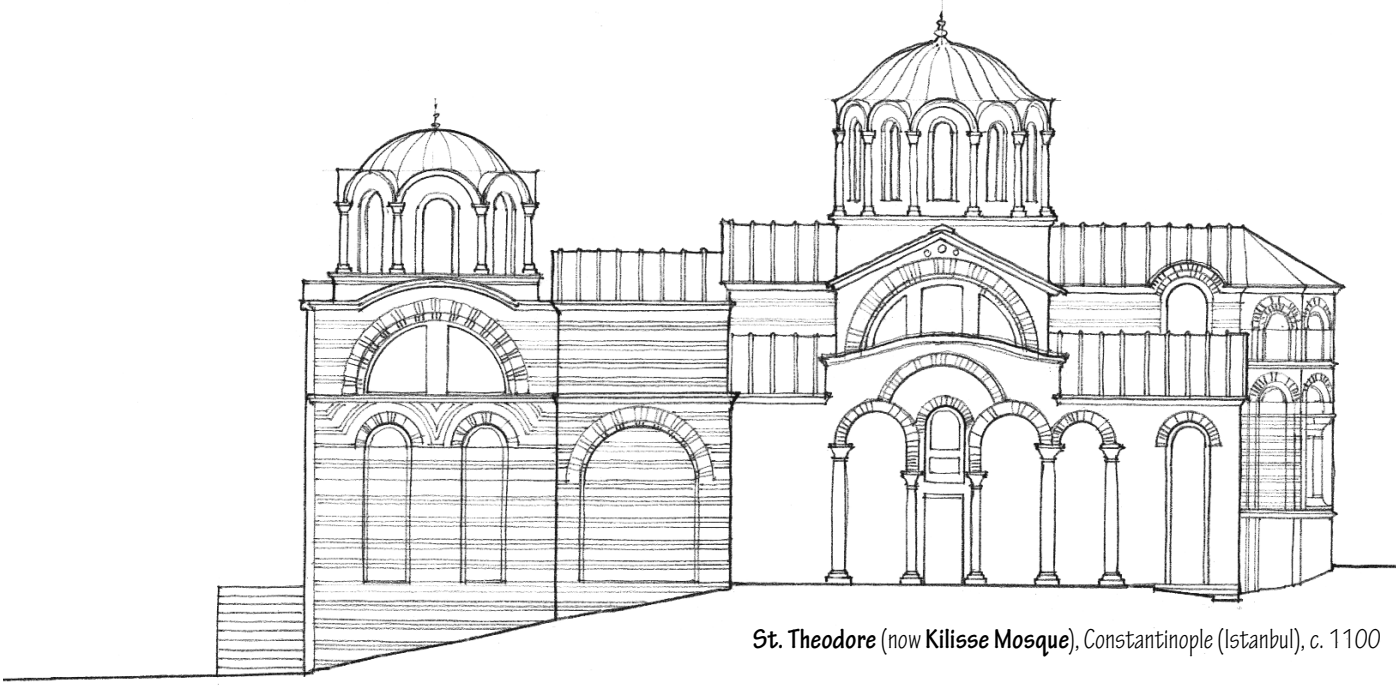


Plan and section: Central circular structures of the **Guachimonton Complex**, Teuchitlán, A.D. 300–800

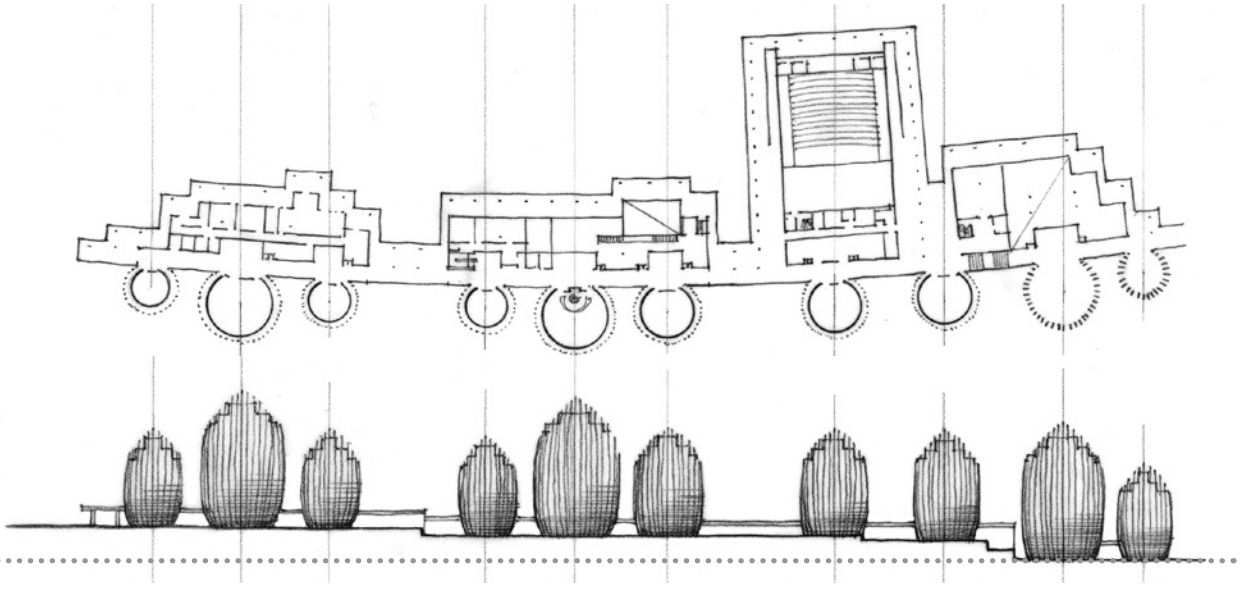


Garden elevation

Art Gallery, Shiraz, Iran, 1970, Alvar Aalto



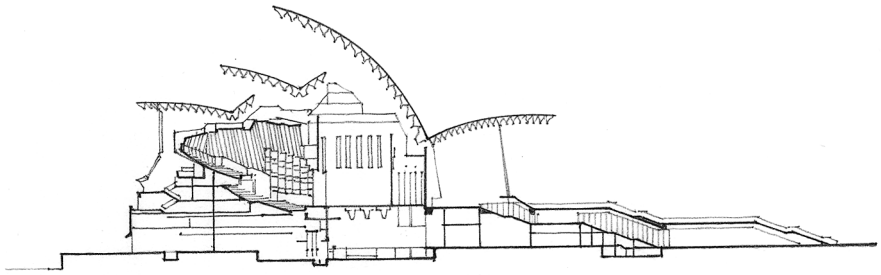
St. Theodore (now **Kilisse Mosque**), Constantinople (Istanbul), c. 1100



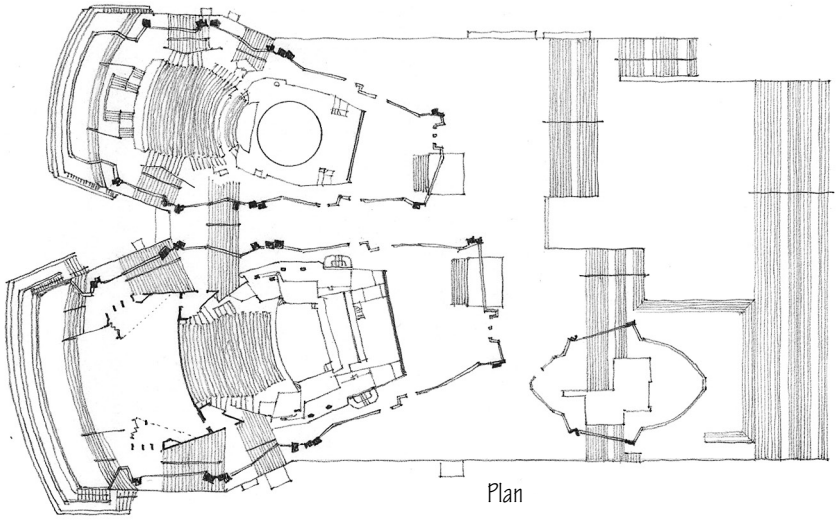
Tjibaou Cultural Center, Nouméa, New Caledonia, 1991–1998, Renzo Piano

REPETITION

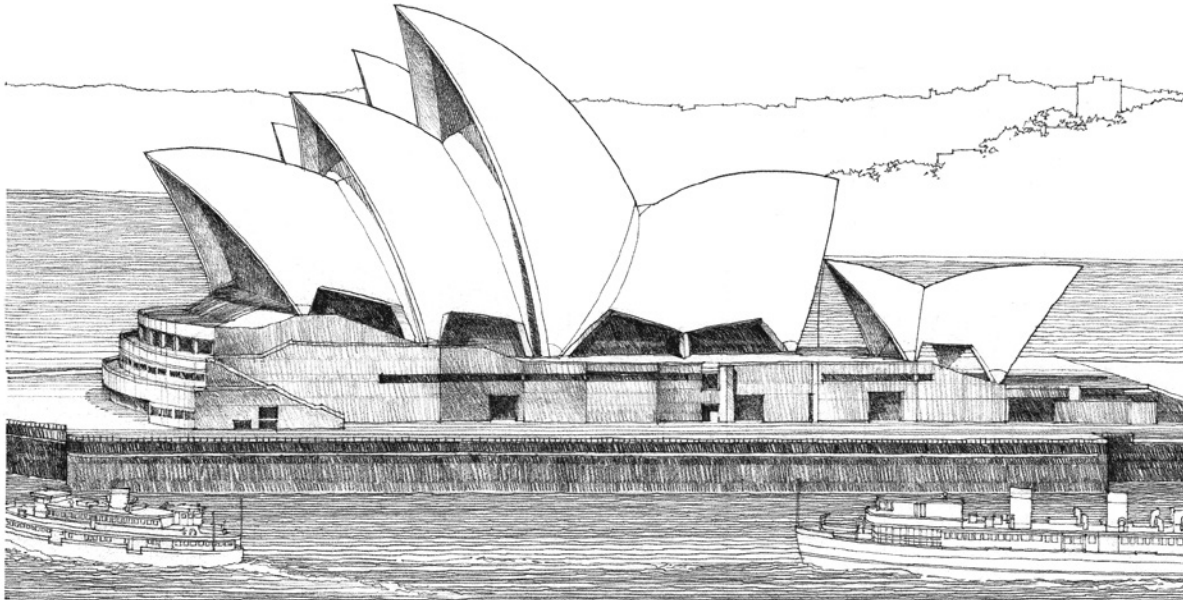
Sydney Opera House, Sydney, Australia, *designed* 1957, *completed* 1973, Jørn Utzon



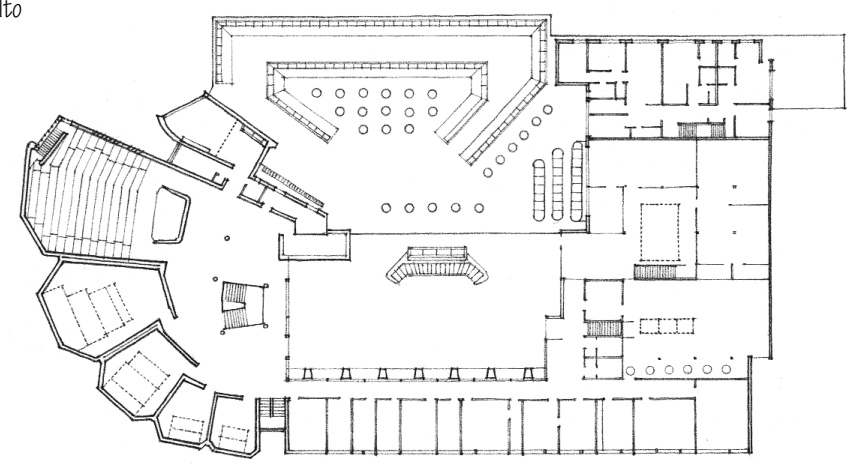
Section



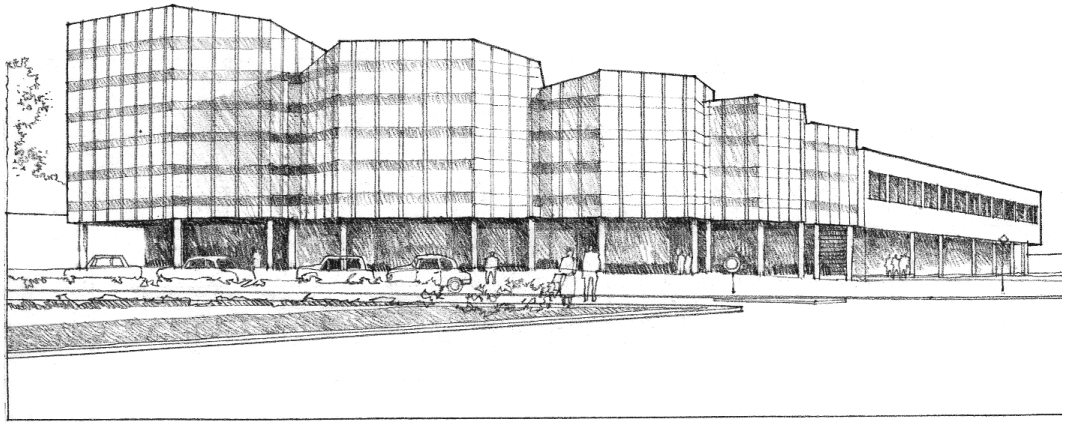
Plan

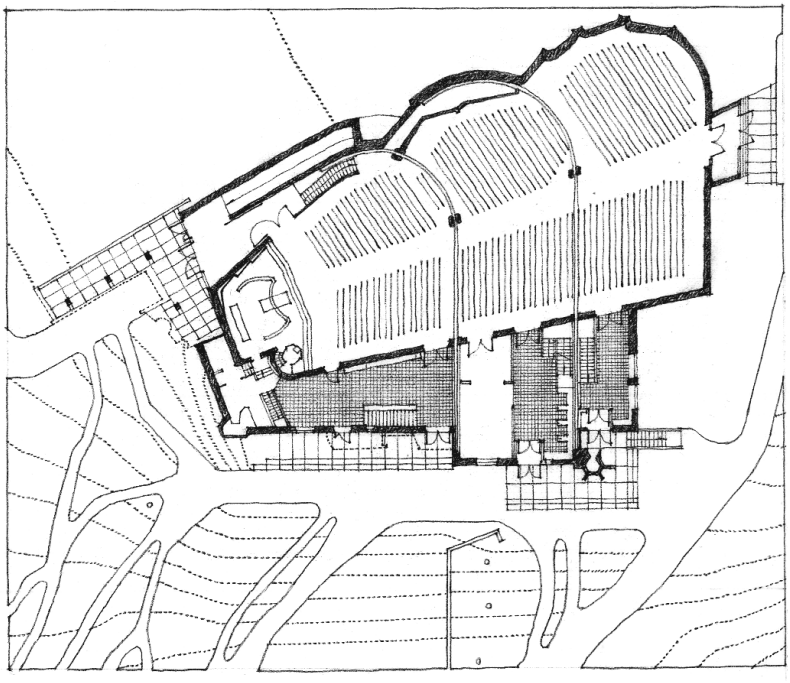


Cultural Center, Wolfsburg, Germany, 1948–1962, Alvar Aalto



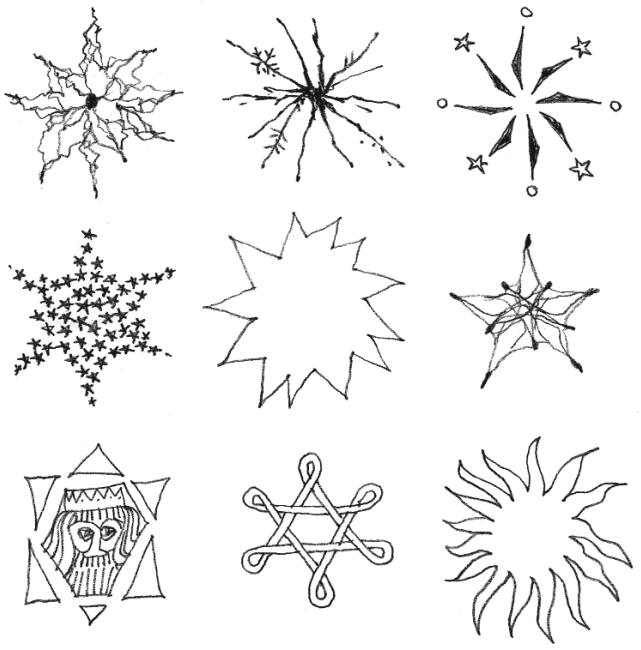
Plan





Church at Vuoksenniska, Finland, 1956, Alvar Aalto

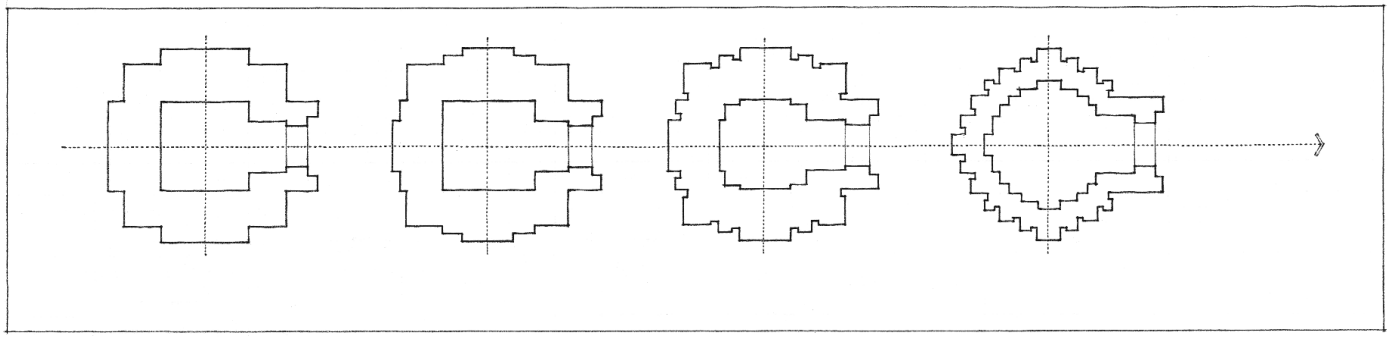
TRANSFORMATION



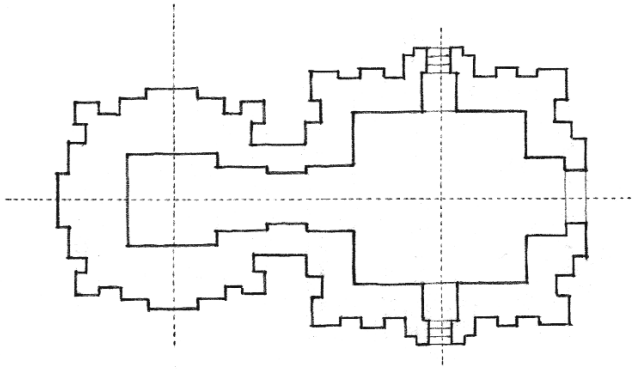
The study of architecture, as with other disciplines, should legitimately involve the study of its past, of prior experiences, endeavors, and accomplishments from which much can be learned and emulated. The principle of transformation accepts this notion; this book, and all of the examples it contains, is predicated on it.

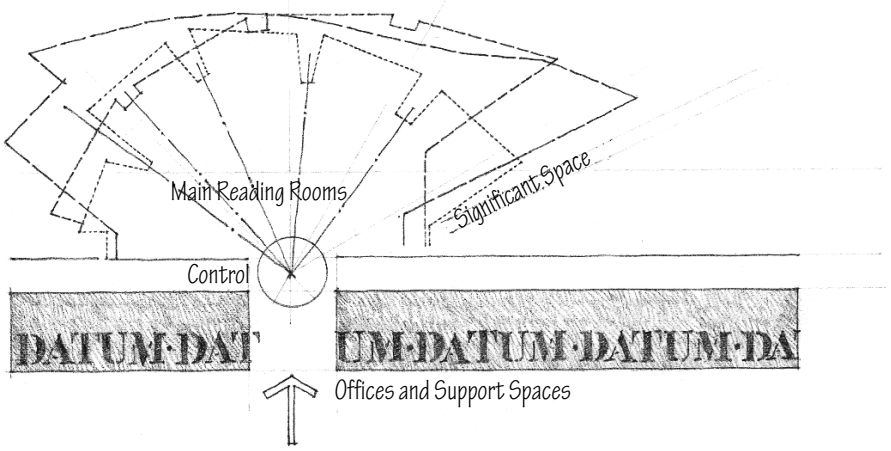
The principle of transformation allows a designer to select a prototypical architectural model whose formal structure and ordering of elements might be appropriate and reasonable, and to transform it through a series of discrete manipulations in order to respond to the specific conditions and context of the design task at hand.

Design is a generative process of analysis and synthesis, of trial and error, of trying out possibilities and seizing opportunities. In the process of exploring an idea and probing its potential, it is essential that a designer understand the fundamental nature and structure of the concept. If the ordering system of a prototypical model is perceived and understood, then the original design concept can, through a series of finite permutations, be clarified, strengthened, and built upon, rather than destroyed.

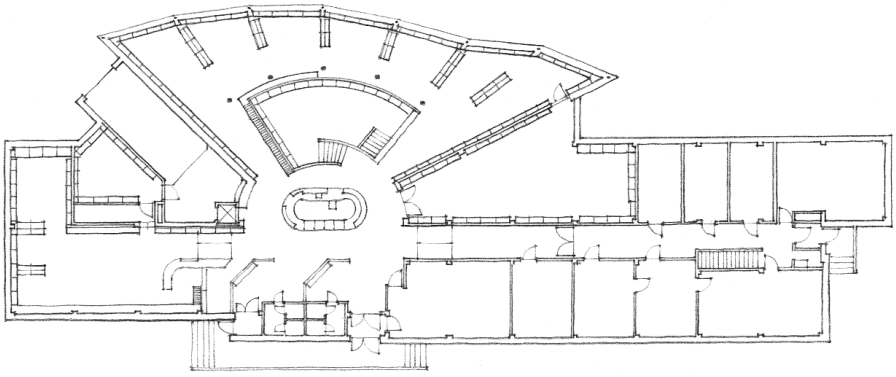


Plan development of the **North Indian Cella**

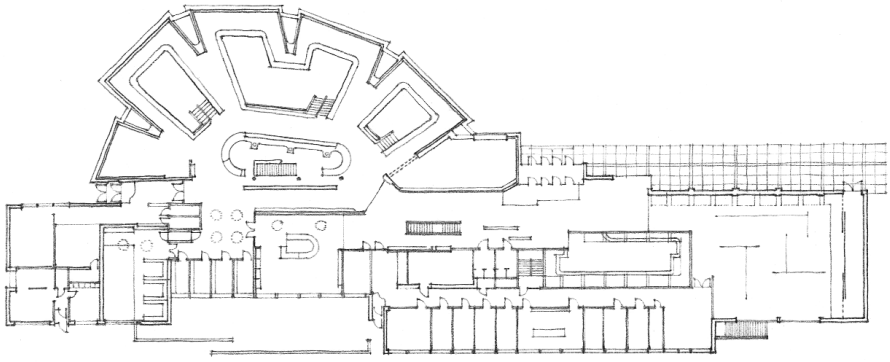




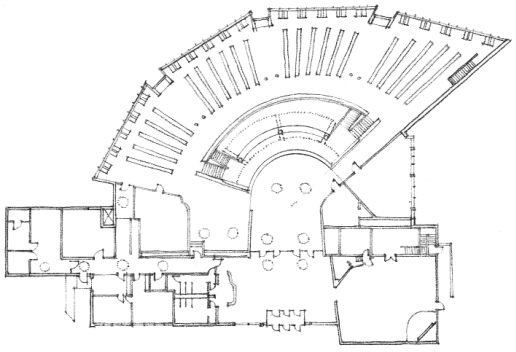
Scheme for 3 libraries by Alvar Aalto



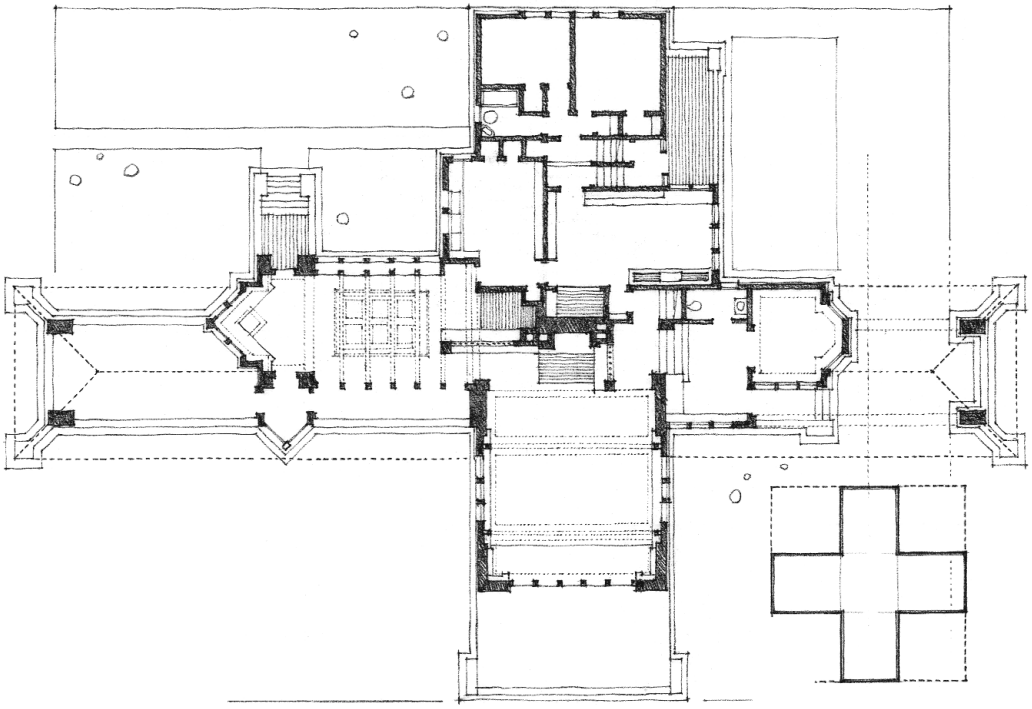
Seinäjoki Public Library, Seinäjoki, Finland, 1963–1965



Rovaniemi City Library, Rovaniemi, Finland, 1963–1968

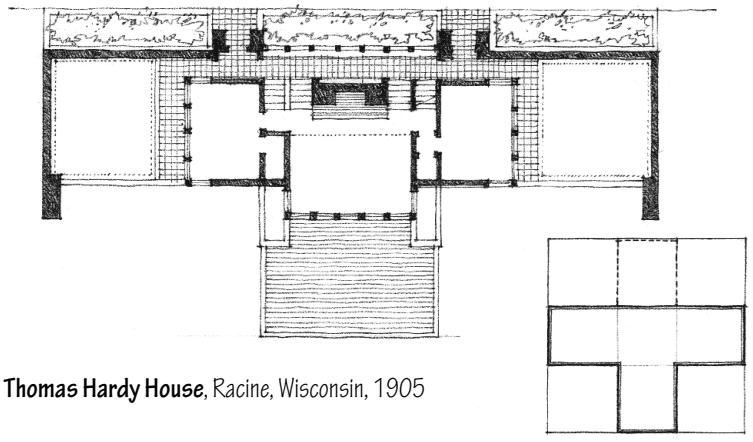


Library of Mount Angel, Benedictine College, Mount Angel, Oregon, 1965–1970

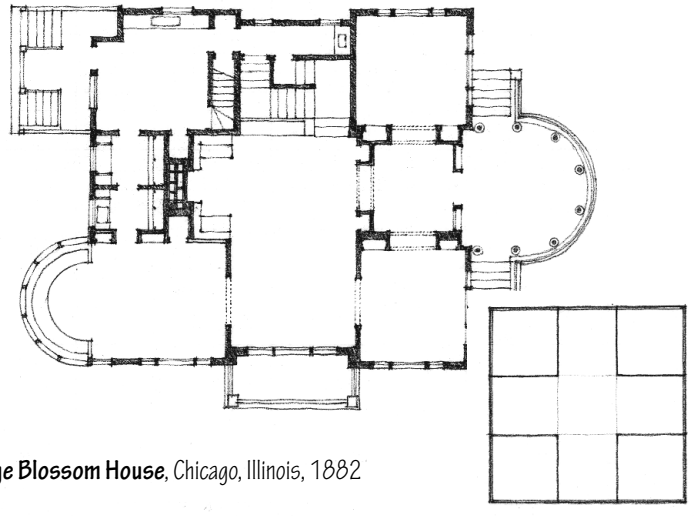


Ward Willitts House, Highland Park, Illinois, 1902

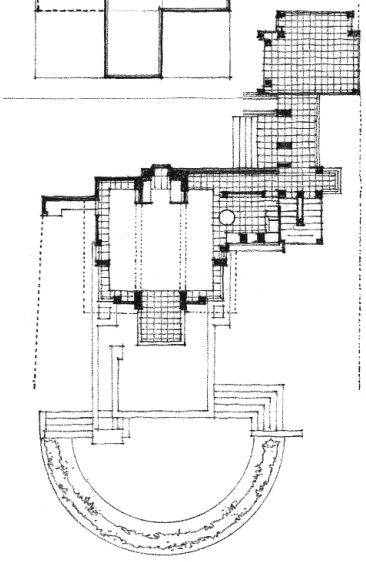
Transformation of a **Cruciform Plan Organization** by Frank Lloyd Wright



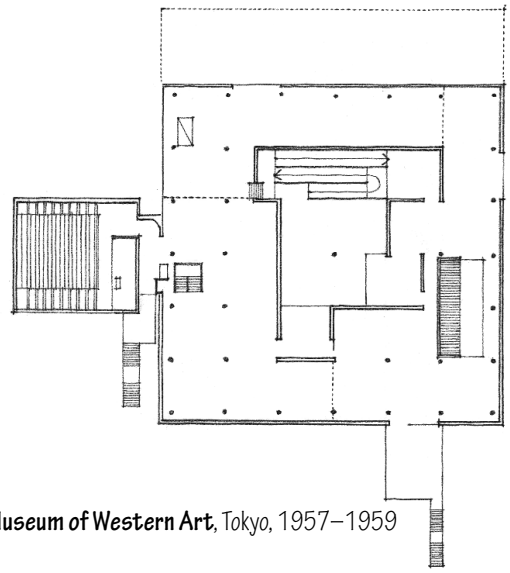
Thomas Hardy House, Racine, Wisconsin, 1905



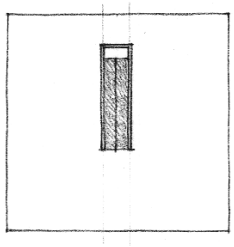
***George* Blossom House**, Chicago, Illinois, 1882

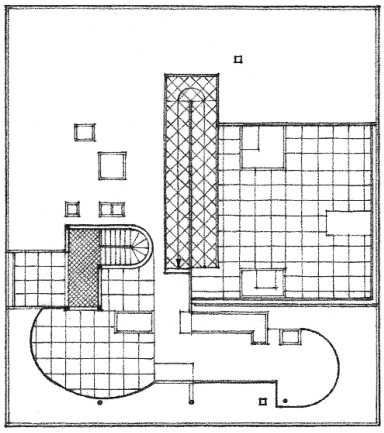


Samuel Freeman House, Los Angeles, California, 1924

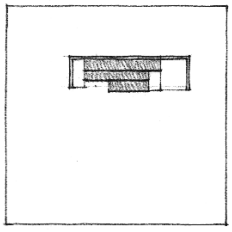


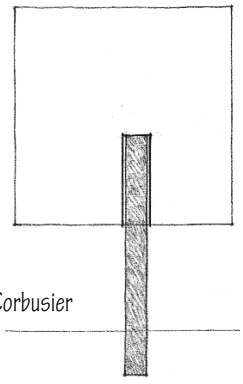
Villa Savoye, Poissy, France, 1928–1931

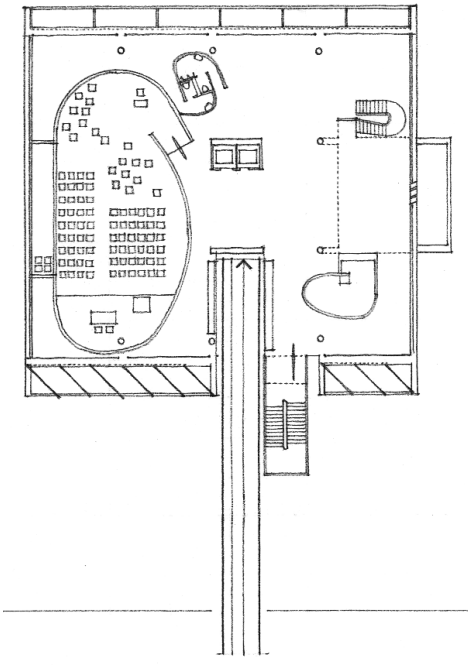




Museum of Western Art, Tokyo, 1957–1959

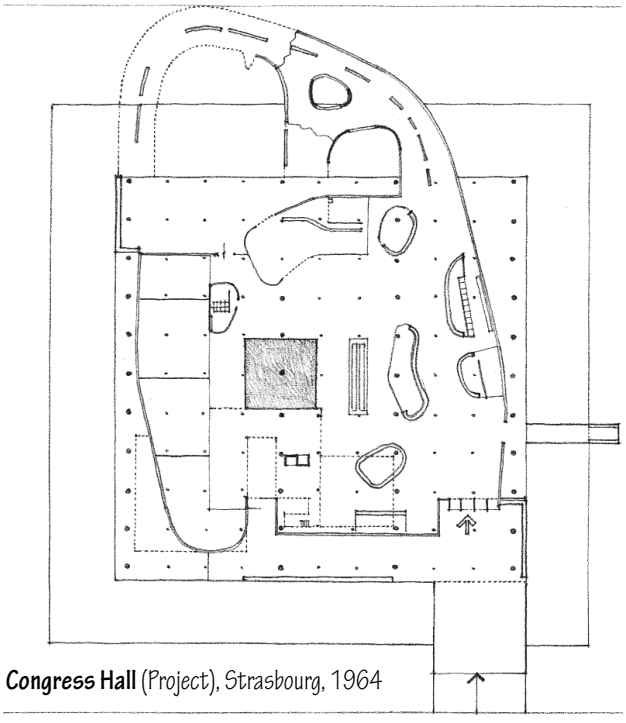


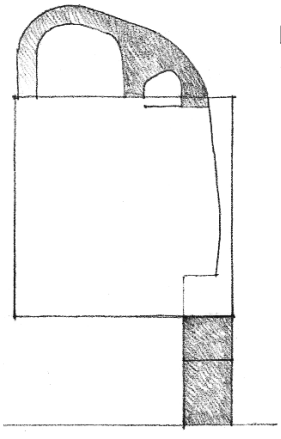




Transformation of a free-plan organization, the **Ramp-in-a-Square**, by Le Corbusier

Millowners' Association Building, Ahmedabad, India, 1954



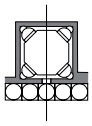


Congress Hall (Project), Strasbourg, 1964

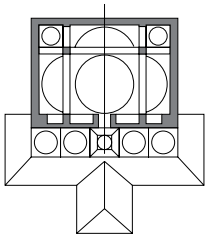
Mimar Sinan (1488–1588), chief architect of the Ottoman Empire, was responsible for the design and construction of several hundred structures in Istanbul and other Turkish cities—mosques, madrasahs, mausoleums, caravanerais, baths, and bridges.

Sinan's mosque designs, from the modest to the most grand, all begin with a central domed space based on a square supporting structure. He achieved larger works by raising the centralized dome and adding semidomes to the sides, resulting in pyramidal compositions. In later designs, the square supporting structure became hexagonal and octagonal in nature.

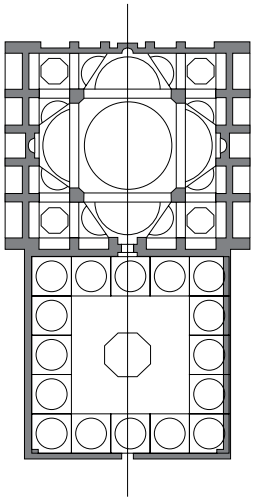
To each centralized space was added a domed arcade or forecourt to mark the entry.



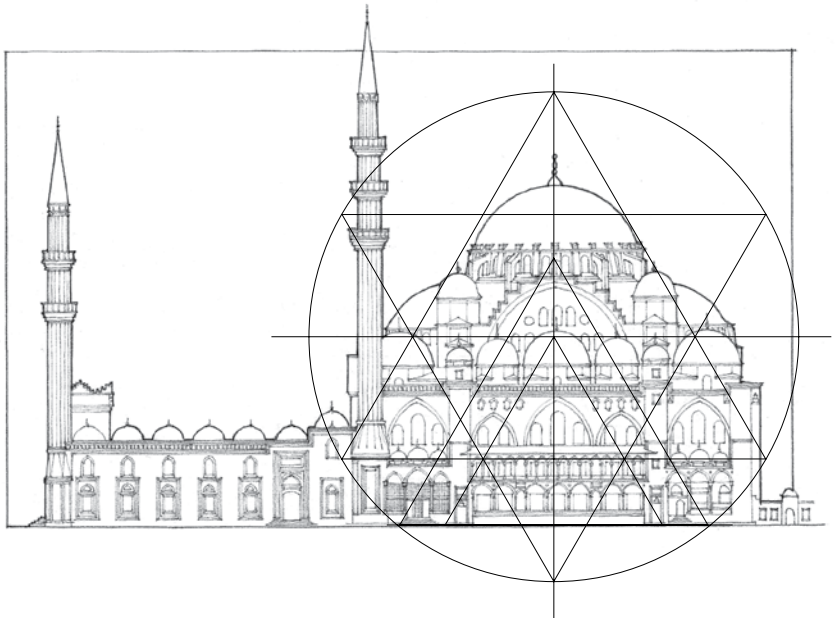
Haseki, Istanbul, 1539



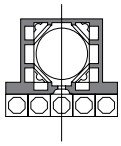
Mihrimah Sultan, Üsküdar, 1540–1548



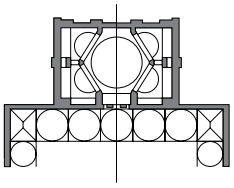
Şehzade, Istanbul, 1543–1548



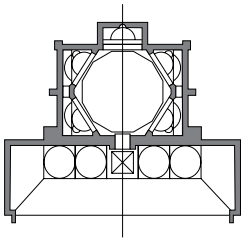
Süleymaniye, Istanbul, 1550–1557



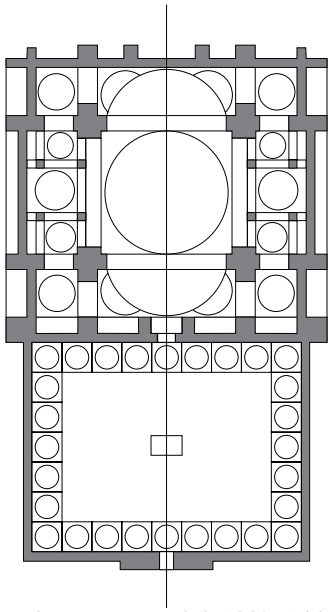
Hadim Ibrahim Pasha,
Istanbul, 1551



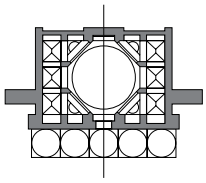
Kara Ahmed Pasha, Topkapi,
1558–1565



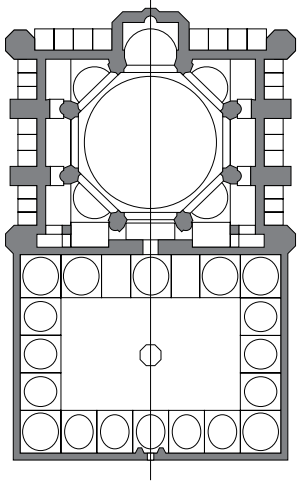
Semizali Pasha, Babaeski, 1565



Süleymaniye, Istanbul, 1550–1557

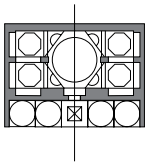


Rüstem Pasha, Istanbul, 1562

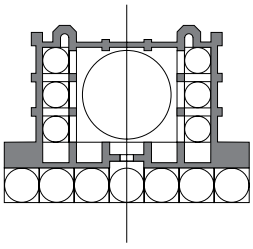


Selimiye, Edirne, 1568–1575

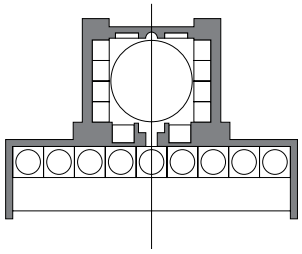
Mosques designed by Mimar Sinan



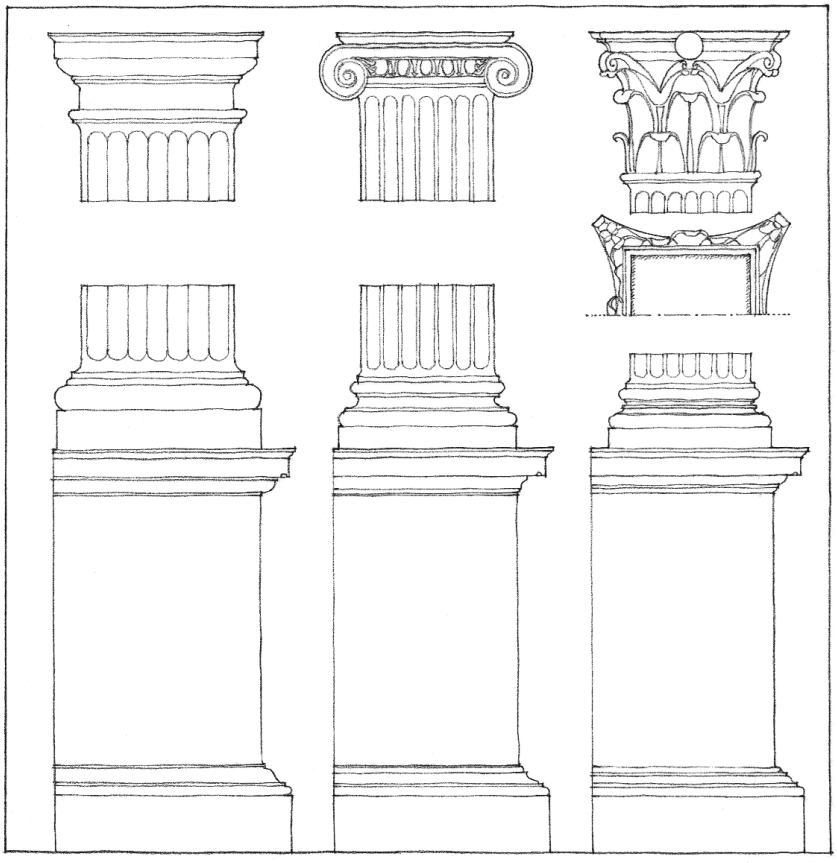
Sinan Pasha, Istanbul, 1555



Mihrimah Sultan, Istanbul,
1562–1565



Sokollu Mehmet Pasha, Lüleburgaz,
1569

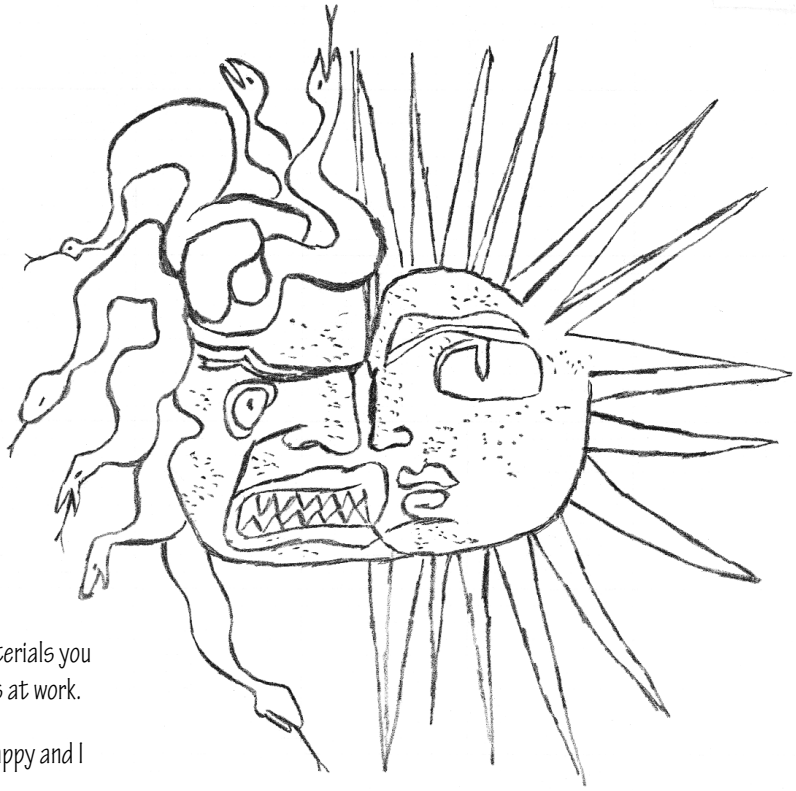


Meaning in Architecture

This book, throughout its presentation of the elements of form and space, has been concerned primarily with the visual aspects of their physical reality in architecture. Points, moving through space and defining lines, lines defining planes, planes defining volumes of form and space. Beyond these visual functions, these elements, by their relationships to one another and the nature of their organization, also communicate notions of domain and place, entry and path of movement, hierarchy and order. These are presented as the literal, denotative meanings of form and space in architecture.

As in language, however, architectural forms and spaces also have connotative meanings: associative values and symbolic content that are subject to personal and cultural interpretation, which can change with time. The spires of a Gothic cathedral can stand for the realm, values, or goals of Christianity. The Greek column can convey the notion of democracy, or, as in America in the early 19th century, the presence of civilization in a new world.

Although the study of connotative meanings, of semiotics and symbology in architecture, is beyond the scope of this book, it should be noted here that architecture, in combining form and space into a single essence, not only facilitates purpose but communicates meaning. The art of architecture makes our existence not only visible but meaningful.



"You employ stone, wood, and concrete, and with these materials you build houses and palaces. That is construction. Ingenuity is at work.

"But suddenly, you touch my heart, you do me good. I am happy and I say: 'This is beautiful.' That is architecture. Art enters in.

"My house is practical. I thank you, as I might thank Railway engineers, or the Telephone service. You have not touched my heart.

"But suppose that walls rise toward heaven in such a way that I am moved. I perceive your intentions. Your mood has been gentle, brutal, charming, or noble. The stones you have erected tell me so. You fix me to the place and my eyes regard it. They behold something which expresses a thought. A thought which reveals itself without wood or sound, but solely by means of shapes which stand in a certain relationship to one another. These shapes are such that they are clearly revealed in light. The relationships between them have not necessarily any reference to what is practical or descriptive. They are a mathematical creation of our mind. They are the language of Architecture. By the use of raw materials and starting from conditions more or less utilitarian, you have established certain relationships which have aroused my emotions. This is Architecture."

Le Corbusier
Towards a New Architecture
1927

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abacus The flat slab forming the top of a column capital, plain in the Doric style, but molded or otherwise enriched in other styles.

abbey A monastery under the supervision of an abbot, or a convent under the supervision of an abbess, belonging to the highest rank of such institutions.

abutment The part of a structure that directly receives thrust or pressure, such as a masonry mass receiving and supporting the thrust of part of an arch or vault; a heavy wall supporting the end of a bridge or span and sustaining the pressure of the abutting earth; a mass or structure resisting the pressure of water on a bridge or pier; or the anchorage for the cables of a suspension bridge.

acanthus A Mediterranean plant whose large, toothed leaves became a common motif in the ornamental program of Corinthian and composite capitals and friezes.

accent A detail that is emphasized by contrasting with its surroundings. Also, a distinctive but subordinate pattern, motif, or color.

accouplement The placement of two columns or pilasters very close together.

acropolis The fortified high area or citadel of an ancient Greek city, esp. the citadel of Athens and site of the Parthenon.

adobe Sun-dried brick made of clay and straw, commonly used in countries with little rainfall.

aedicule A canopied opening or niche flanked by two columns, piers, or pilasters supporting a gable, lintel, or entablature.

agora A marketplace or public square in an ancient Greek city, usually surrounded with public buildings and porticoes and commonly used as a place for popular or political assembly.

aisle Any of the longitudinal divisions of a church, separated from the nave by a row of columns or piers. Also, a walkway between or along sections of seats in a theater, auditorium, church, or other place of assembly.

alcazar A castle or fortress of the Spanish Moors.

allée French term for a narrow passage between houses, or a broad walk planted with trees.

amalaka The bulbous, ribbed stone finial of a sikhara in Indian architecture.

ambulatory The covered walk of an atrium or cloister. Also, an aisle encircling the end of the choir or chancel of a church, originally used for processions.

amphitheater An oval or round building with tiers of seats around a central arena, as those used in ancient Rome for gladiatorial contests and spectacles. Also, a level area of oval or circular shape surrounded by rising ground.

anomaly A deviation from the normal or expected form, order, or arrangement.

anthropology The science of human beings: specifically, the study of the origins, physical and cultural development, and environmental and social relations of humankind.

anthropometry The measurement and study of the size and proportions of the human body.

anthropomorphism A conception or representation resembling the human form or having human attributes.

apadana The grand columnar audience hall in a Persian palace.

apse A semicircular or polygonal projection of a building, usually vaulted and used esp. at the sanctuary or east end of a church.

arabesque A complex and ornate design that employs flowers, foliage, and sometimes animal and geometric figures to produce an intricate pattern of interlaced lines.

arbor A shady shelter of shrubs and branches or of latticework intertwined with climbing vines and flowers.

arcade A series of arches supported on piers or columns. Also, an arched, roofed gallery or passageway with shops on one or both sides.

arch A curved structure for spanning an opening, designed to support a vertical load primarily by axial compression.

architrave The lowermost division of a classical entablature, resting directly on the column capitals and supporting the frieze.

arcuate Curved or arched like a bow: a term used in describing the arched or vaulted structure of a Romanesque church or Gothic cathedral, as distinguished from the trabeated architecture of an Egyptian hypostyle hall or Greek Doric temple.

ashlar A squared building stone finely dressed on all faces adjacent to those of other stones so as to permit very thin mortar joints.

atrium Originally, the main or central inner hall of an ancient Roman house, open to the sky at the center and usually having a pool for the collection of rainwater. Later, the forecourt of an early Christian church, flanked or surrounded by porticoes. Now, an open, skylit court around which a house or building is built.

axis A central line that bisects a two-dimensional body or figure or about which a three-dimensional body or figure is symmetrical. Also, a straight line to which elements in a composition are referred for measurement or symmetry.

background The part of an image represented as being at the maximum distance from the frontal plane.

balance A state of equilibrium between contrasting, opposing, or interacting elements. Also, the pleasing or harmonious arrangement or proportion of parts or elements in a design or composition.

balcony An elevated platform projecting from the wall of a building and enclosed by a railing or parapet.

baldachin An ornamental canopy of stone or marble permanently placed over the high altar in a church.

baluster Any of a number of closely spaced supports for a railing. Also called banister.

baptistery A part of a church or a separate building in which the rite of baptism is administered.

base The lowermost portion of a wall, column, pier, or other structure, usually distinctively treated and considered as an architectural unit.

basilica A large oblong building used as a hall of justice and public meeting place in ancient Rome, typically having a high central space lit by a clerestory and covered by timber trusses, and a raised dais in a semicircular apse for the tribunal. The Roman basilica served as a model for early Christian basilicas, which were characterized by a long, rectangular plan, a high colonnaded nave lit by a clerestory and covered by a timbered gable roof, two or four lower side aisles, a semicircular apse at the end, a narthex, and often other features, as an atrium, a bema, and small semicircular apses terminating the aisles.

GLOSSARY

batter A backward slope of the face of a wall as it rises.

bay A major spatial division, usually one of a series, marked or partitioned off by the principal vertical supports of a structure. Also, any of a number of principal compartments or divisions of a wall, roof, or other part of a building marked off by vertical or transverse supports.

beam A rigid structural member designed to carry and transfer transverse loads across space to supporting elements.

bearing wall A wall capable of supporting an imposed load, as from a floor or roof of a building.

belvedere A building, or architectural feature of a building, designed and situated to look out upon a pleasing scene.

bema A transverse open space separating the nave and the apse of an early Christian church, developing into the transept of later cruciform churches.

berm A bank of earth placed against one or more exterior walls of a building as protection against extremes in temperature.

blind Describing a recess in a wall having the appearance of a window (blind window) or door (blind door), inserted to complete a series of windows or to provide symmetry of design.

bosket A grove or thicket of trees in a garden or park.

brise-soleil A screen, usually of louvers, placed on the outside of a building to shield the windows from direct sunlight.

buttress An external support built to stabilize a structure by opposing its outward thrusts, esp. a projecting support built into or against the outside of a masonry wall.

campanile A bell tower, usually one near but not attached to the body of a church.

cantilever A beam or other rigid structural member extending beyond a fulcrum and supported by a balancing member or a downward force behind the fulcrum.

capital The distinctively treated upper end of a column, pillar, or pier, crowning the shaft and taking the weight of the entablature or architrave.

caravansary An inn in the Near East for the overnight accommodation of caravans, usually having a large courtyard enclosed by a solid wall and entered through an imposing gateway.

caryatid A sculptured female figure used as a column.

catenary The curve assumed by a perfectly flexible, uniform cable suspended freely from two points not in the same vertical line. For a load that is uniformly distributed in a horizontal projection, the curve approaches that of a parabola.

cathedral The principal church of a diocese, containing the bishop's throne called the cathedra.

ceiling The overhead interior surface or lining of a room, often concealing the underside of the floor or roof above.

cella The principal chamber or enclosed part of a classical temple, where the cult image was kept. Also called naos.

cenotaph A monument erected in memory of a deceased person whose remains are buried elsewhere.

chaitya A Buddhist shrine in India, usually carved out of solid rock on a hillside, having the form of an aisled basilica with a stupa at one end.

chancel The space about the altar of a church for the clergy and choir, often elevated above the nave and separated from it by a railing or screen.

chapel A subordinate or private place of worship or prayer.

chatri In Indian architecture, a roof-top kiosk or pavilion having a dome usually supported on four columns.

chattri An umbrella-shaped finial symbolizing dignity, composed of a stone disk on a vertical pole.

church A building for public Christian worship.

clerestory A portion of an interior rising above adjacent rooftops and having windows admitting daylight to the interior. Also, the uppermost section of a Gothic nave characterized by a series of large windows rising above adjacent rooftops to admit daylight to the interior.

cloister A covered walk having an arcade or colonnade on one side opening onto a courtyard.

colonnade A series of regularly spaced columns supporting an entablature and usually one side of a roof structure.

column A rigid, relatively slender structural member designed primarily to support compressive loads applied at the member ends. In classical architecture, a cylindrical support consisting of a capital, shaft, and usually a base, either monolithic or built up of drums the full diameter of the shaft.

computer graphics The field of computer science that studies methods and techniques for creating, representing, and manipulating image data by computer technology; the digital images so produced. Architectural applications of computer graphics range from two-dimensional architectural drawing to three-dimensional modeling and energy, lighting, and acoustic simulations of building performance.

computer modeling The use of computer technology and mathematical algorithms to create abstract models of systems and processes to simulate their behavior. For architectural applications, computer modeling software enables the creation and manipulation of virtual, three-dimensional models of existing or proposed buildings and environments for analysis, testing, and appraisal.

concrete An artificial, stonelike building material made by mixing cement and various mineral aggregates with sufficient water to cause the cement to set and bind the entire mass.

contrast Opposition or juxtaposition of dissimilar elements in a work of art to intensify each element's properties and produce a more dynamic expressiveness.

corbel To set bricks or stones in an overlapping arrangement so that each course steps upward and outward from the vertical face of a wall.

cornice The uppermost member of a classical entablature, consisting typically of a cymatium, corona, and bed molding.

corona The projecting, slablike member of a classical cornice, supported by the bed molding and crowned by the cymatium.

corridor A narrow passageway or gallery connecting parts of a building, esp. one into which several rooms or apartments open.

cortile A large or principal courtyard of an Italian palazzo.

court An area open to the sky and mostly or entirely surrounded by walls or buildings.

courtyard A court adjacent to or within a building, esp. one enclosed on all four sides.

cromlech A circular arrangement of megaliths enclosing a dolmen or burial mound.

cross ventilation The circulation of fresh air through open windows, doors, or other openings on opposite sides of a room.

cupola A light structure on a dome or roof, serving as a belfry, lantern, or belvedere. Also, a small dome covering a circular or polygonal area.

curtain wall An exterior wall supported wholly by the structural frame of a building and carrying no loads other than its own weight and wind loads.

cyma recta A projecting molding having the profile of a double curve with the concave part projecting beyond the convex part.

cymatium The crowning member of a classical cornice, usually a cyma recta.

dado The major part of a pedestal between the base and the cornice or cap. Also, the lower portion of an interior wall when faced or treated differently from the upper section, as with paneling or wallpaper.

datum Any level surface, line, or point used as a reference for the positioning or arrangement of elements in a composition.

diagrid Contraction for diagonal + grid: the exterior lattice-like framework of a building created by crisscrossing diagonal members and unifying the vertical-load-carrying function of columns and the lateral-load resistance of angled braces, while horizontal rings or belts serve to triangulate the frame, restrain it from buckling, and counter any outward expansion.

dian A palace hall in Chinese architecture, always on the median axis of the site plan and constructed on a raised platform faced with brick or stone.

dolmen A prehistoric monument consisting of two or more large upright stones supporting a horizontal stone slab, found esp. in Britain and France and usually regarded as a tomb.

dome A vaulted structure having a circular plan and usually the form of a portion of a sphere, so constructed as to exert an equal thrust in all directions.

dormer A projecting structure built out from a sloping roof, usually housing a vertical window or ventilating louver.

dougong A bracket system used in traditional Chinese construction to support roof beams, project the eaves outward, and support the interior ceiling. The absence of a triangular tied frame in Chinese architecture made it necessary to multiply the number of supports under the rafters. In order to reduce the number of pillars this would normally require, the area of support afforded by each pillar was increased by the dougong. The main beams support the roof through intermediary queen posts and shorter upper beams, enabling the roof to be given a concave curve. This distinctive curve is believed to have developed at the beginning of the Tang period, presumably to lighten the visual weight of the roof and allow more daylight into the interior.

eclecticism A tendency in architecture and the decorative arts to freely mix various historical styles with the aim of combining the virtues of diverse sources, or of increasing allusive content, particularly during the second half of the 19th century in Europe and the United States.

emphasis Stress or prominence given to an element of a composition by means of contrast, anomaly, or counterpoint.

enfilade An axial arrangement of doorways connecting a series of rooms so as to provide a vista down the entire length of the suite. Also, an axial arrangement of mirrors on opposite sides of a room so as to give an effect of an infinitely long vista.

engaged column A column built so as to be truly or seemingly bonded to the wall before which it stands.

entablature The horizontal section of a classical order that rests on the columns, usually composed of a cornice, frieze, and architrave.

entasis A slight convexity given to a column to correct an optical illusion of concavity if the sides were straight.

envelope The physical shell of a building, consisting of the exterior walls, windows, doors, and roof that protect and shelter interior spaces from the exterior environment.

ergonomics An applied science concerned with the characteristics of people that need to be considered in the design of devices and systems in order that people and things will interact effectively and safely.

exedra A room or covered area open on one side and provided with seats, used as a meeting place in ancient Greece and Rome. Also, a large apsidal extension of the interior volume of a church, normally on the main axis.

facade The front of a building or any of its sides facing a public way or space, esp. one distinguished by its architectural treatment.

fascia One of the three horizontal bands making up the architrave in the Ionic order. Also, any broad, flat, horizontal surface, as the outer edge of a cornice or roof.

field A region or expanse of space characterized by a particular property, feature, or activity.

fenestration The design, proportioning, and disposition of windows and other exterior openings of a building. Also, an ornamental motif having the form of a blind arcade or arch, as in medieval cabinetwork.

figure A shape or form, as determined by outlines or exterior surfaces. Also, a combination of geometric elements disposed in a particular form or shape.

figure-ground A property of perception in which there is a tendency to see parts of a visual field as solid, well-defined objects standing out against a less distinct background.

finial A relatively small, usually foliated ornament terminating the peak of a spire or pinnacle.

floor The level, base surface of a room or hall upon which one stands or walks. Also, a continuous supporting surface extending horizontally throughout a building, having a number of rooms and constituting one level in the structure.

flying buttress An inclined bar of masonry carried on a segmental arch and transmitting an outward and downward thrust from a roof or vault to a solid buttress that through its mass transforms the thrust into a vertical one; a characteristic feature of Gothic construction.

GLOSSARY

form The shape and structure of something as distinguished from its substance or material. Also, the manner of arranging and coordinating the elements and parts of a composition so as to produce a coherent image; the formal structure of a work of art.

forum The public square or marketplace of an ancient Roman city, the center of judicial and business affairs, and a place of assembly for the people, usually including a basilica and a temple.

fresco The art or technique of painting on a freshly spread, moist plaster surface with pigments ground up in water or a limewater mixture.

frieze The horizontal part of a classical entablature between the cornice and architrave, often decorated with sculpture in low relief. Also, a decorative band, as one along the top of an interior wall, immediately below the cornice, or a sculptured one in a stringcourse on an outside wall.

gable The triangular portion of wall enclosing the end of a pitched roof from cornice or eaves to ridge.

galleria A spacious promenade, court, or indoor mall, usually having a vaulted roof and lined with commercial establishments.

gallery A long, relatively narrow room or hall, esp. one for public use and having architectural importance through its scale or decorative treatment. Also, a roofed promenade, esp. one extending inside or outside along the exterior wall of a building.

garbha-griha A "womb chamber," the dark, innermost sanctuary of a Hindu temple, where the statue of the deity is placed.

gestalt A unified configuration, pattern, or field of specific properties that cannot be derived from the summation of the component parts.

Gestalt psychology The theory or doctrine that physiological or psychological phenomena do not occur through the summation of individual elements, as reflexes or sensations, but through gestalts functioning separately or interrelatedly.

Golden Section A proportion between the two dimensions of a plane figure or the two divisions of a line, in which the ratio of the smaller to the larger is the same as the ratio of the larger to the whole: a ratio of approximately 0.618 to 1.000.

gopura A monumental, usually ornate gateway tower to a Hindu temple enclosure, esp. in southern India.

gridshell A form-active structure that derives its strength from its double-curved surface geometry; pioneered in the 1940s by Frei Otto.

groin vault A compound vault formed by the perpendicular intersection of two vaults, forming arched diagonal arrises called groins. Also called cross vault.

ground The main surface or background in painting or decorative work. Also, the receding part of a visual field against which a figure is perceived.

hall The large entrance room of a house or building, as a vestibule or lobby. Also, a large room or building for public gatherings or entertainment.

hacienda A large, landed estate for farming and ranching in North and South American areas once under Spanish influence. Also, the main house on such an estate.

haiden The hall of worship of a Shinto shrine, usually in front of the honden.

harmonic progression A sequence of numbers whose reciprocals form an arithmetic progression.

harmony The orderly, pleasing, or congruent arrangement of the elements or parts in an artistic whole.

hashira A sacred post in Shinto architecture, shaped by human hands.

hierarchy A system of elements ranked, classified, and organized one above another, according to importance or significance.

hippodrome An arena or structure for equestrian and other spectacles. Also, an open-air stadium with an oval track for horse and chariot races in ancient Greece and Rome.

hypostyle hall A large hall having many columns in rows supporting a flat roof, and sometimes a clerestory: prevalent in ancient Egyptian and Achaemenid architecture.

in antis Between antae, the rectangular piers or pilasters formed by thickening the end of a projecting wall.

intercolumniation A system for spacing columns in a colonnade based on the space between two adjacent columns measured in diameters.

interfenestration A space between two windows. Also, the art or process of arranging the openings in a wall.

interstitial Forming an intervening space.

intrados The inner curve or surface of an arch forming the concave underside.

iwan A large vaulted hall serving as an entrance portal and opening onto a courtyard: prevalent in Parthian, Sassanian, and later in Islamic architecture. Also, ivan, liwan.

jami masjid Friday mosque: A congregational mosque for public prayer, esp. on Fridays.

joist Any of a series of small, parallel beams for supporting floors, ceilings, or flat roofs.

Ka'ba A small, cubical stone building in the courtyard of the Great Mosque at Mecca containing a sacred black stone and regarded by Muslims as the House of God, the objective of their pilgrimages, and the point toward which they turn in praying.

keystone The wedge-shaped, often embellished voussoir at the crown of an arch, serving to lock the other voussoirs in place. Until the keystone is in place, no true arch action is incurred.

kondo Golden Hall: the sanctuary where the main image of worship is kept in a Japanese Buddhist temple. The Jodo, Shinshu, and Nicheiren sects of Buddhism use the term "hondo" for this sanctuary, the Shingon and Tendai sects use "chudo," and the Zen sect uses "butsuden."

lacunar A ceiling, soffit, or vault decorated with a pattern of recessed panels.

lantern A superstructure crowning a roof or dome having open or windowed walls to let in light and air.

linga A phallus, symbol of the god Siva in Hindu architecture.

lingdao The spirit way that led from the south gate to a royal tomb of the Tang dynasty, lined with stone pillars and sculptured animal and human figures.

lintel A beam supporting the weight above a door or window opening.

loggia A colonnaded or arcaded space within the body of a building but open to the air on one side, often at an upper story overlooking an open court. The loggia is an important feature of the architecture of the Italian palazzi.

louver An opening fitted with slanting, fixed or movable slats to admit air but exclude rain and snow or to provide privacy. Also, a finned or vaned device for controlling the radiation from a light source.

madrasah A Muslim theological school arranged around a courtyard and attached to a mosque, found from the 11th century on in Egypt, Anatolia, and Persia.

mandala A diagram of the cosmos, often used to guide the design of Indian temple plans.

mandapa A large, porchlike hall leading to the sanctuary of a Hindu or Jain temple and used for religious dancing and music.

mass The physical volume or bulk of a solid body.

massing A unified composition of two-dimensional shapes or three-dimensional volumes, esp. one that has or gives the impression of weight, density, and bulk.

mastaba An ancient Egyptian tomb made of mud brick, rectangular in plan with a flat roof and sloping sides, from which a shaft leads to underground burial and offering chambers.

mausoleum A large and stately tomb, esp. that in the form of a building for housing the tombs of many individuals, often of a single family.

megalith A very large stone used as found or roughly dressed, esp. in ancient construction work.

megaron A building or semi-independent unit of a building, typically having a rectangular principal chamber with a center hearth and a porch, often of columns in antis: traditional in Greece since Mycenaean times and believed to be the ancestor of the Doric temple.

menhir A prehistoric monument consisting of an upright megalith, usually standing alone but sometimes aligned with others.

mezzanine A low or partial story between two main stories of a building, esp. one that projects as a balcony and forms a composition with the story beneath it.

mihrab A niche or decorative panel in a mosque designating the qibla.

minaret A lofty, slender tower attached to a mosque, having stairs leading up to one or more projecting balconies from which the muezzin calls the Muslim people to prayer.

mirador In Spanish architecture, an architectural feature affording a view of the surroundings, as a bay window, loggia, or roof pavilion.

model An example serving as a pattern for imitation or emulation in the creation of something.

module A unit of measurement used for standardizing the dimensions of building materials or regulating the proportions of an architectural composition.

monastery A place of residence for a community of persons living in seclusion under religious vows, esp. monks.

monolith A single block of stone of considerable size, often in the form of an obelisk or column.

mosque A Muslim building or place of public worship.

mullion A vertical member between the lights of a window or the panels in wainscoting.

muqarnas A system of decoration in Islamic architecture, formed by the intricate corbeling of brackets, squinches, and inverted pyramids; sometimes wrought in stone but more often in plaster. Also called stalactite work.

mural A large picture painted on or applied directly to a wall or ceiling surface.

naos *See* **cella**.

narthex The portico before the nave of an early Christian or Byzantine church, appropriated to penitents. Also, an entrance hall or vestibule leading to the nave of a church.

nave The principal or central part of a church, extending from the narthex to the choir or chancel and usually flanked by aisles.

necropolis A historic burial ground, esp. a large, elaborate one of an ancient city.

niche An ornamental recess in a wall, often semicircular in plan and surmounted by a half-dome, as for a statue or other decorative object.

nuraghe Any of the large, round or triangular stone towers found in Sardinia and dating from the second millennium B.C. to the Roman conquest.

obelisk A tall, four-sided shaft of stone that tapers as it rises to a pyramidal point, originating in ancient Egypt as a sacred symbol of the sun-god Ra and usually standing in pairs astride temple entrances.

oculus A circular opening, esp. one at the crown of a dome.

order A condition of logical, harmonious, or comprehensible arrangement in which each element of a group is properly disposed with reference to other elements and to its purpose. Also, an arrangement of columns supporting an entablature, each column comprising a capital, shaft, and usually a base.

oriel A bay window supported from below by corbels or brackets.

orthographic Pertaining to, involving, or composed of right angles.

pagoda A Buddhist temple in the form of a square or polygonal tower with roofs projecting from each of its many stories, erected as a memorial or to hold relics. From the stupa, the Indian prototype, the pagoda gradually changed in form to resemble the traditional multistoried watch tower as it spread with Buddhism to China and Japan. Pagodas were initially of timber, but from the 6th century on, were more frequently of brick or stone, possibly due to Indian influence.

pailou A monumental gateway in Chinese architecture, having a trabeated form of stone or wood construction with one, three, or five openings and often bold projecting roofs, erected as a memorial at the entrance to a palace, tomb, or sacred place: related to the Indian toranas and the Japanese torii. Also, pailoo.

palazzo A large, imposing public building or private residence, esp. in Italy.

Palladian motif A window or doorway in the form of a round-headed archway flanked on either side by narrower compartments, the side compartments being capped with entablatures on which the arch of the central compartment rests.

panopticon A building, as a prison, hospital, library, or the like, so arranged that all parts of the interior are visible from a single point.

pantheon A temple dedicated to all the gods of a people. Also, a public building serving as the burial place of or containing the memorials to the famous dead of a nation.

GLOSSARY

parapet A low, protective wall at the edge of a terrace, balcony, or roof, esp. that part of an exterior wall, fire wall, or party wall that rises above the roof.

parterre An ornamental arrangement of flower beds of different shapes and sizes.

parti Used by the French at the École des Beaux-Arts in the 19th century, the design idea or sketch from which an architectural project will be developed. Now, the basic scheme or concept for an architectural design, represented by a diagram.

passage grave A megalithic tomb of the Neolithic and early Bronze Ages found in the British Isles and Europe, consisting of a roofed burial chamber and narrow entrance passage, covered by a tumulus: believed to have been used for successive family or clan burials spanning a number of generations.

pavilion A light, usually open building used for shelter, concerts, or exhibits, as in a park or fair. Also, a central or flanking projecting subdivision of a facade, usually accented by more elaborate decoration or greater height and distinction of skyline.

pedestal A construction upon which a column, statue, memorial shaft, or the like, is elevated, usually consisting of a base, a dado, and a cornice or cap.

pediment The low-pitched gable enclosed by the building's horizontal and raking cornices of a Greek or Roman temple. Also, a similar or derivative element used to surmount a major division of a facade or crown an opening.

pendentive A spherical triangle forming the transition from the circular plan of a dome to the polygonal plan of its supporting structure.

pergola A structure of parallel colonnades supporting an open roof of beams and crossing rafters or trelliswork, over which climbing plants are trained to grow.

peristyle A colonnade surrounding a building or a courtyard. Also, the courtyard so enclosed.

piano nobile The principal story of a large building, as a palace or villa, with formal reception and dining rooms, usually one flight above the ground floor.

piazza An open square or public place in a city or town, esp. in Italy.

pier A vertical supporting structure, as a section of wall between two openings or one supporting the end of an arch or lintel. Also, a cast-in-place concrete foundation formed by boring with a large auger or excavating by hand a shaft in the earth to a suitable bearing stratum and filling the shaft with concrete.

pilaster A shallow rectangular feature projecting from a wall, having a capital and a base and architecturally treated as a column.

pillar An upright, relatively slender shaft or structure, usually of brick or stone, used as a building support or standing alone as a monument.

piloti A column of steel or reinforced concrete supporting a building above an open ground level, thereby leaving the space available for other uses.

Platonic solid One of the five regular polyhedrons: tetrahedron, hexahedron, octahedron, dodecahedron, or icosahedron.

plaza A public square or open space in a city or town.

plinth The usually square slab beneath the base of a column, pier, or pedestal. Also, a continuous, usually projecting course of stones forming the base or foundation of a wall.

podium A solid mass of masonry visible above ground level and serving as the foundation of a building, esp. the platform forming the floor and substructure of a classical temple.

porch An exterior appendage to a building, forming a covered approach or vestibule to a doorway.

porte-cochère A porch roof projecting over a driveway at the entrance to a building and sheltering those getting in or out of vehicles. Also, a vehicular passageway leading through a building or screen wall into an interior courtyard.

portico A porch or walkway having a roof supported by columns, often leading to the entrance of a building.

post A stiff vertical support, esp. a wooden column in timber framing.

postern A private or side entrance, as one for pedestrians next to a porte-cochère.

prism A polyhedron having ends that are parallel, congruent polygons and sides that are parallelograms.

promenade An area used for a stroll or walk, esp. in a public place, as for pleasure or display.

proportion The comparative, proper, or harmonious relation of one part to another or to the whole with respect to magnitude, quantity, or degree. Also, the equality between two ratios in which the first of the four terms divided by the second equals the third divided by the fourth.

propylaeum A vestibule or gateway of architectural importance before a temple area or other enclosure. Often used in the plural, propylaea.

propylon A freestanding gateway having the form of a pylon and preceding the main gateway to an ancient Egyptian temple or sacred enclosure.

prototype An early and typical example that exhibits the essential features of a class or group and on which later stages are based or judged.

proxemics The study of the symbolic and communicative role of the spatial separation individuals maintain in various social and interpersonal situations, and how the nature and degree of this spatial arrangement relates to environmental and cultural factors.

pylon A monumental gateway to an ancient Egyptian temple, consisting either of a pair of tall truncated pyramids and a doorway between them or of one such masonry mass pierced with a doorway, often decorated with painted reliefs.

pyramid A massive masonry structure having a rectangular base and four smooth, steeply sloping sides facing the cardinal points and meeting at an apex, used in ancient Egypt as a tomb to contain the burial chamber and the mummy of the pharaoh. The pyramid was usually part of a complex of buildings within a walled enclosure, including mastabas for members of the royal family, an offering chapel, and a mortuary temple. A raised causeway led from the enclosure down to a valley temple on the Nile, where purification rites and mummification were performed. Also, a masonry mass having a rectangular base and four stepped and sloping faces culminating in a single apex, used in ancient Egypt and pre-Columbian Central America as a tomb or a platform for a temple.

qibla The direction toward which Muslims face to pray, esp. the Ka'ba at Mecca. Also, the wall in a mosque in which the mihrab is set, oriented to Mecca.

quoin An external solid angle of a wall, or one of the stones forming such an angle, usually differentiated from the adjoining surfaces by material, texture, color, size, or projection.

rampart A broad embankment of earth raised as a fortification around a place and usually surmounted by a parapet.

rath A Hindu temple cut out of solid rock to resemble a chariot.

ratio Relation in magnitude, quantity, or degree between two or more similar things.

reentrant Reentering or pointing inward, as an interior angle of a polygon that is greater than 180°.

regular Having all faces congruent regular polygons and all solid angles congruent.

repetition The act or process of repeating formal elements or motifs in a design.

rhythm Movement characterized by a patterned repetition or alternation of formal elements or motifs in the same or a modified form.

roof The external upper covering of a building, including the frame for supporting the roofing.

room A portion of space within a building, separated by walls or partitions from other similar spaces.

rustication Ashlar masonry having the visible faces of the dressed stones raised or otherwise contrasted with the horizontal and usually the vertical joints, which may be rabbeted, chamfered, or beveled.

sanctuary A sacred or holy place, esp. the most sacred part of a church in which the principal altar is placed, or an especially holy place in a temple.

scale A proportion determining the relationship of a representation to that which it represents. Also, a certain proportionate size, extent, or degree, usually judged in relation to some standard or point of reference.

semiotics The study of signs and symbols as elements of communicative behavior.

shell structure A thin, rigid, curved surface structure formed to enclose a volume. Applied loads develop compressive, tensile, and shear stresses acting within the plane of the shell. The thinness of the shell, however, has little bending resistance and is unsuitable for concentrated loads.

shoro A structure from which the temple bell is hung, as one of a pair of small, identical, symmetrically placed pavilions in a Japanese Buddhist temple.

shrine A building or other shelter, often of a stately or sumptuous character, enclosing the remains or relics of a saint or other holy person and forming an object of religious veneration and pilgrimage.

sikhara A tower of a Hindu temple, usually tapered convexly and capped by an amalaka.

sill The lowest horizontal member of a frame structure, resting on and anchored to a foundation wall. Also, the horizontal member beneath a door or window opening.

smart facade Cladding designed to conserve and reduce the energy needed for heating, cooling, and lighting a building by integrating passive solar collection, solar shading, daylighting, thermal resistance, and natural ventilation into its assembly.

solarium A glass-enclosed porch, room, or gallery used for sunbathing or for therapeutic exposure to sunlight.

solid A geometric figure having the three dimensions of length, breadth, and thickness.

space The three-dimensional field in which objects and events occur and have relative position and direction, esp. a portion of that field set apart in a given instance or for a particular purpose.

spandrel The triangular-shaped, sometimes ornamented area between the extrados of two adjoining arches, or between the left or right extrados of an arch and the rectangular framework surrounding it. Also, a panel-like area in a multistory frame building, between the sill of a window on one level and the head of a window immediately below.

spire A tall, acutely tapering pyramidal structure surmounting a steeple or tower.

stair One of a flight or series of steps for going from one level to another, as in a building.

stalactite work See **muquarna**.

steeple A tall ornamental structure, usually ending in a spire and surmounting the tower of a church or other public building.

stele An upright stone slab or pillar with a carved or inscribed surface, used as a monument or marker, or as a commemorative tablet in the face of a building.

stoa An ancient Greek portico, usually detached and of considerable length, used as a promenade or meeting place around public places.

story A complete horizontal division of a building, having a continuous or nearly continuous floor and comprising the space between two adjacent levels. Also, the set of rooms on the same floor or level of a building.

stringcourse A horizontal course of brick or stone flush with or projecting beyond the face of a building, often molded to mark a division in the wall.

stupa A Buddhist memorial mound erected to enshrine a relic of Buddha and to commemorate some event or mark a sacred spot. Modeled on a funerary tumulus, it consists of an artificial dome-shaped mound raised on a platform, surrounded by an outer ambulatory with a stone vedika and four toranas, and crowned by a chattri. The name for the stupa in Ceylon is "dagoba," and in Tibet and Nepal, "chorten."

symbology The study of use of symbols.

symbol Something that represents something else by association, resemblance, or convention, esp. a material object used to represent something invisible or immaterial, deriving its meaning chiefly from the structure in which it appears.

symmetry The exact correspondence in size, form, and arrangement of parts on opposite sides of a dividing line or plane, or about a center or axis. Also, regularity of form or arrangement in terms of like, reciprocal, or corresponding parts.

synagogue A building or place of assembly for Jewish worship and religious instruction.

ta A pagoda in Chinese architecture.

GLOSSARY

technology Applied science: the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science.

tectonics The art and science of shaping, ornamenting, or assembling materials in building construction.

temenos In ancient Greece, a piece of ground specially reserved and enclosed as a sacred place.

tensile structure A thin, flexible surface that carries loads primarily through the development of tensile stresses.

terrace A raised level with a vertical or sloping front or sides faced with masonry, turf, or the like, esp. one of a series of levels rising above one another.

tetrastyle Having four columns on one or each front.

tholos A circular building in classical architecture.

threshold A place or point of entering or beginning.

tokonoma Picture recess: a shallow, slightly raised alcove for the display of a flower arrangement or a kakemono, a vertical hanging scroll containing either text or a painting. One side of the recess borders the outside wall of the room through which light enters, while the interior side adjoins the tana, a recess with built-in shelving. As the spiritual center of a traditional Japanese house, the tokonoma is located in its most formal room.

topography The physical configuration and features of a site, area, or region.

torana An elaborately carved, ceremonial gateway in Indian Buddhist and Hindu architecture, having two or three lintels between two posts.

torii A monumental, freestanding gateway on the approach to a Shinto shrine, consisting of two pillars connected at the top by a horizontal crosspiece and a lintel above it, usually curving upward.

trabeate Of or pertaining to a system of construction employing beams or lintels. Also, trabeated.

transept The major transverse part of a cruciform church, crossing the main axis at a right angle between the nave and choir. Also, either of the projecting arms of this part, on either side of the central aisle of a church.

transformation The process of changing in form or structure through a series of discrete permutations and manipulations in response to a specific context or set of conditions without a loss of identity or concept.

trellis A frame supporting open latticework, used as a screen or a support for growing vines or plants.

trullo A circular stone shelter of the Apulia region of southern Italy, roofed with conical constructions of corbeled dry masonry, usually whitewashed and painted with figures or symbols. Many trulli are over 1000 years old and still in use today, usually located among vineyards to serve as storage structures or as temporary living quarters during the harvest.

truss A structural frame based on the geometric rigidity of the triangle and composed of linear members subject only to axial tension or compression.

tumulus An artificial mound of earth or stone, esp. over an ancient grave.

tympanum The recessed triangular space enclosed by the horizontal and raking cornices of a triangular pediment, often decorated with sculpture. Also, a similar space between an arch and the horizontal head of a door or window below.

uniformity The state or quality of being identical, homogeneous, or regular.

unity The state or quality of being combined into one, as the ordering of elements in an artistic work that constitutes a harmonious whole or promotes a singleness of effect.

vault An arched structure of stone, brick, or reinforced concrete, forming a ceiling or roof over a hall, room, or other wholly or partially enclosed space. Since it behaves as an arch extended in a third dimension, the longitudinal supporting walls must be buttressed to counteract the thrusts of the arching action.

veranda A large, open porch, usually roofed and partly enclosed, as by a railing, often extending across the front and sides of a house.

vestibule A small entrance hall between the outer door and the interior of a house or building.

vihara A Buddhist monastery in Indian architecture often excavated from solid rock, consisting of a central pillared chamber surrounded by a verandah onto which open small sleeping cells. Adjacent to this cloister was a courtyard containing the main stupa.

villa A country residence or estate.

void An empty space contained within or bounded by mass.

volume The size or extent of a three-dimensional object or region of space, measured in cubic units.

wainscot A facing of wood paneling, esp. when covering the lower portion of an interior wall.

wall Any of various upright constructions presenting a continuous surface and serving to enclose, divide, or protect an area.

wat A Buddhist monastery or temple in Thailand or Cambodia.

ziggurat A temple-tower in Sumerian and Assyrian architecture, built in diminishing stages of mud brick with buttressed walls faced with burnt brick, culminating in a summit shrine or temple reached by a series of ramps: thought to be of Sumerian origin, dating from the end of the 3rd millennium B.C.

Abbey Church, Alpirsbach, Germany, 439
Abu Simbel, Great Temple of Rameses II, 278
The Acropolis, Athens, Greece, 134, 288
Adler House (Project), Philadelphia, Pennsylvania, 274
Administration Building, Johnson Wax Co., Racine, Wisconsin, 297
A.E. Bingham House, Santa Barbara, California, 399
AEG Pavilion, German Shipbuilding Exhibition of 1908, Berlin, 56
Agora of Assos, Asia Minor, 78
Agora of Ephesus, Asia Minor, 41
Agora Plan, Athens, 417
Agora Plan at Priene, 187
Alhambra, Granada, Spain, 222, 288
Altes Museum, Berlin, 15
Amédée Ozenfant House, Paris, 199
Angkor Wat, Cambodia, 379
Architect's Studio, Helsinki, 172
Architectural Design Study, 105
Arch of Septimius Severus, Rome, 166
Arnheim Pavilion, The Netherlands, 178
Art Gallery, Shiraz, Iran, 446

Bacardi Office Building (Project), Santiago de Cuba, 21
Baker House, MIT, Cambridge, Massachusetts, 253
Bakong Temple, Cambodia, 432
Bandung Institute of Technology, Indonesia, 152
Banff Community Recreation Center, Alberta, Canada, 64
Bank of England, London, England, 265
Baptistery at Pisa, Italy, 5
Barn in Ontario, Canada, 30
The Basilica, Vicenza, Italy, 15, 103
Bathhouse, Jewish Community Center, Trenton, New Jersey, 41
Baths of Caracalla, Rome, 379, 395
Bauhaus Museum Competiton Co-Winning Entry, 268
Bay Window of the Living Room, Hill House, Scotland, 203
Bedford Park, London, England, 441
Beijing Plan, China, 387
Bell Tower, Church at Vuoksenniska, Imatra, Finland, 10
Benacerraf House Addition, Princeton, New Jersey, 70
Berlin Building Exposition House, 173, 205
Beth Sholom Synagogue, Elkins Park, Pennsylvania, 74
Bibliotheca Alexandrina (Alexandrian Library), Alexandria, Egypt, 92
Bibliothèque Nationale (Project), 153
Bjergsted Financial Park, Bjergsted, Norway, 96
Bookstaver House, Westminster, Vermont, 309
Borobodur, Indonesia, 313
Boston City Hall, Massachusetts, 123
Brick House, New Canaan, Connecticut, 25
Bridge House (Project), 251
Buddhist Chaitya Hall at Karli, Maharashtra, India, 31
Burroughs Adding Machine Company, Detroit, Michigan, 77
Busan Cinema Center, Busan, South Korea, 66
Busan Opera House (Proposal), Korea, 66
Buseoksa Temple, Gyeongsangdo, Korea, 284
Business Men's Assurance Co. of America, Kansas City, Missouri, 273

Ca d'Oro, Venice, 400
Canberra Plan, Australia, 259
Can Lis, Porto Petro, Majorca, 252
Canterbury Cathedral, England, 306
Capitol Complex (Project), Islamabad, Pakistan, 434
Capitol Complex at Dacca, Bangladesh, 243
Caplin House, Venice, California, 231
Carpenter Center for the Visual Arts, Harvard University, Cambridge, Massachusetts, 286, 308
Caryatid Porch, The Erechtheion, Athens, 11
Cary House, Mill Valley, California, 17
Casa de Música, Porto, Portugal, 60
Catholic Church, Taos, New Mexico, 285
CBS Building, New York City, 108
Cenotaph for Sir Isaac Newton, 5
Centraal Beheer Insurance Offices, Apeldoorn, Netherlands, 50, 274
Centralized Plans (Serlio), 237
Central Pavilion, Horyu-Ji Temple, Nara, Japan, 37
Centre Le Corbusier, Zurich, Switzerland, 149, 423
Centrosoyus Building, Kirova Ulitsa, Moscow, 397
Cerro Paranal, Atacama Desert, Chile, 411
Champ de Mars, Paris, 176
Chancellery Building, French Embassy (Project), Brasilia, 90
Chapel, Massachusetts Institute of Technology, Cambridge, Massachusetts, 44
Chapel Space, Notre Dame Du Haut, Ronchamp, France, 197
China Central Television Headquarters (CCTV), Beijing, China, 51
Chinese Courtyard House, Beijing, China, 390
Chinese patio house, 188
Chiswick House, London, England, 229
Chongqing Taoyuanju Community Center, Chongqing, China, 151
Church at Vuoksenniska, Imatra, Finland, 10, 25, 449
Church of Christ the Worker, Atlántida, Uruguay, 398
Circus Plan at Bath, England, 253
Cistercian Monastery of La Tourette, France, 137, 153
City of Justice, Barcelona, Spain, 48
Civic Center Plan, Isfahan, Persia, 378, 425
Cloister and Salle des Chevaliers, Mont S. Michel, France, 161
Cloister of Moissac Abbey, France, 16
Color Construction (Project for a Private House), 205
The Colosseum, Rome, 379
Column of Marcus Aurelius, Piazza Colonna, Rome, 10
Column of St. Theodore, Venice, 292
Commonwealth Promenade Apartments, Chicago, Illinois, 103
Composition of Nine Squares, 232
Conceptual Diagram, Museum of Modern Art, Gunma Prefecture, Japan, 86
Concert Hall (Project), 24
Condominium Unit No. 5, Sea Ranch, California, 160
Congress Hall (Project), Strasbourg, France, 453
Conical Cenotaph Project, 44
Convent for the Dominican Sisters (project), Media, Pennsylvania, 183
Convention Hall for Chicago (Project), 147
Coonley Playhouse, Riverside, Illinois, 47
Cooroy Art Temple, Cooroy Mountain, Australia, 124
Cornell University Undergraduate Housing (Project), Ithaca, New York, 12
Country House in Brick (Project), 23
Courtyard House Project, 47
Crawford Art Gallery, Cork, Ireland, 97

INDEX OF BUILDINGS

Crown Hall, School of Architecture and Urban Design, Illinois Institute of Technology, Chicago, 13, 339
Cruciform Plan Organization, 452
Crystal Palace, London, England, 273
Cultural Center (Competition Entry), Leverkusen, Germany, 419
Cultural Center, Wolfsburg, Germany, 449
Cummins Indianapolis Distribution Headquarters, Indianapolis, Indiana, 332

Darwin D. Martin House and Estate, Buffalo, New York, 389
Des Moines Public Library, Iowa, 191
DeVore House (Project), Montgomery County, Pennsylvania, 418
Dialogue Center "Upheavals," Szczecin, Poland, 150
Dilwara Jain Temples, Mt. Abu, India, 434
Doge's Palace, Venice, 292
Dogon Housing Cluster, Southeastern Mali, West Africa, 84
Dolmen, 26
Dom-ino House Project, 162
Doric Temple at Segesta, Sicily, 30
Dr. Currutchet's House, La Plata, Argentina, 292
Dura-Europos Plan, Syria, 272
Durbar Square, Patan, Nepal, 416

Early Megaron Space, 184
East Building, National Gallery of Art, Washington, D. C., 301
Eastern State Penitentiary, Philadelphia, Pennsylvania, 311
East Harlem Preschool, New York City, 137
Eden Project Biodomes, Cornwall, England, 269
Edwin Cheney House, Oak Park, Illinois, 289
Einstein Tower, Potsdam, Germany, 104
Emperor's Seat, Imperial Palace, Kyoto, Japan, 21
Empire State Building, New York City, 378
EOS Housing, Helsingborg, Sweden, 253
The Erechtheion, Athens, 11
Eric Boissonas House II, Cap Benat, France, 321
Eric Boissonas House I, New Canaan, Connecticut, 277
ESO (European Southern Observatory) Hotel, Cerro Paranal, Atacama Desert, Chile, 411
Ethiopian Orthodox Tewahedo Church (Project), Stockholm, Sweden, 92
Everson Museum, Syracuse, New York, 102
Eyüp Cultural Center, Istanbul, Turkey, 124

Fallingwater (Kaufmann House), Pennsylvania, 27, 207, 267, 289
Farnsworth House, Plano, Illinois, 136, 320
Fatehpur Sikri, Palace Complex of Akbar the Great, Mogul Emperor of India, 45, 132, 261
Federation Square, Melbourne, Australia, 115
Finnish Pavilion, New York World's Fair, 24
Fire Temple at Sarvistan, Iran, 426
First Unitarian Church, Rochester, New York, 109, 409
Florence, Italy, 405
Florey Building, Queen's College, Oxford, 182
Fontenay Abbey, Burgundy, France, 189
Forbidden City, Beijing, 135, 136, 285, 387
Foro Boca Concert Hall, Boca Del Rio, Mexico, 59
Forum at Pompeii, 187
Frank Lloyd Wright Studio, Oak Park, Illinois, 400
Frederic C. Hamilton Building, Denver Art Museum, Denver, Colorado, 61
French Embassy, Basilia, Brazil, 80
Friedman House, Pleasantville, New York, 269
Fukuoka Sogo Bank, Study of the Saga Branch, 108

Gagarin House, Peru, Vermont, 300
Galleria Vittorio Emanuelle II, Milan, Italy, 176
Gamble House, Pasadena, California, 267
Gandhi Ashram Museum, Ahmedabad, India, 276
Gavotte I, Sixth Cello Suite, 412
George Blossom House, Chicago, Illinois, 452
Georgia O'Keefe Residence, Abiquiu, northwest of Sante Fe, New Mexico, 17
German Pavilion (Barcelona Pavilion), Barcelona, 167
German Pavilion, Montreal World Exposition, 422
Germigny-des-Prés, France, 434
Ggantija Temple Complex, Malta, 85
The Gherkin. *See* St. Mary Axe, London, UK
Giron Square, Colombia, South America, 128
Glass House, New Canaan, Connecticut, 131, 148, 166, 225, 286
G. N. Black House (Kragsyde), Manchester-by-the Sea, Massachusetts, 83
Gorman Residence, Amagansett, New York, 69
Grand Staircase, Paris Opera House, 330
Great Pyramid of Cheops at Giza, Egypt, 40, 45, 378
Great Stupa at Sanchi, India, 393
Greek Temples, 184
Greenhouse House, Salisbury, Connecticut, 243
Guachimonton Complex, Teuchitlán, Mexico, 446
Guggenheim Museum, Bilbao, Spain, 259
Guggenheim Museum, New York City, 242, 313
Gunma Prefectural Museum of Fine Arts, Japan, 86
Gwathmey Residence, Amagansett, New York, 53, 70

Habitat Israel, Project, Jerusalem, 85
Habitat Montreal, Canada, 85
Hadim Ibrahim Pasha, Istanbul, 455
Hadrian's Villa, Tivoli, Italy, 90, 220, 300
Hagia Sophia, Constantinople (Istanbul), Turkey, 240, 379
Hale County Animal Shelter, Greensboro, Alabama, 147
Hanamaruki Miso-Making Experience, Ina, Nagano, Japan, 61
Hangar, Design I, 25
Hanselmann House, Fort Wayne, Indiana, 45
The Hans Rosling Center for Population Health, Seattle, Washington, 111
Hasan Pasha Han, Istanbul, Turkey, 445
Haseki, Istanbul, 454
Hattenbach Residence, Santa Monica, California, 87
Haystack Mountain School of Arts and Crafts, Deer Isle, Maine, 309
Hearst Tower, New York City, 51
Heathcote (Hemingway House), Ilkley, Yorkshire, England, 405
Henry Babson House, Riverside, Illinois, 79
Herbert F. Johnson House (Wingspread), Wind Point, Wisconsin, 256
High Court, Chandigarh, India, 269, 297
Hill House, Helensburgh, Scotland, 203
Himeji Castle, Himeji, Japan, 439
Hines House, Sea Ranch, California, 307
History Faculty Building, Cambridge University, England, 172, 408
Hoffman House, East Hampton, New York, 107
Horyu-Ji Temple, Nara, Japan, 37, 75, 216, 415
Hospital Project, Venice, 274, 314
Hôtel Amelot, Paris, 406

Hôtel de Beauvais, Paris, 392
Hôtel de Matignon, Paris, 390
Hôtel Dieu (Hospital), 255
Hotel for Students at Otaniemi, Finland, 185
House 10 (Project), 12, 251
House at Poissy, 71
House at Stabio, Ticino, Switzerland, 69
House at Stuttgart, 71
House, Berlin Building Exposition, 173, 205
House for Dr. Bartholomeusz, Colombo, Sri Lanka, 57
House for Mrs. Robert Venturi, Chestnut Hill, Pennsylvania, 264, 296
House III for Robert Miller, Lakeville, Connecticut, 95
House in Milwaukee, Wisconsin, 299
House in Old Westbury, New York, 177, 307, 331
House MM, Palma de Mallorca, Spain, 266
House No. 33, Priene, 188
House of the Faun, Pompeii, 445
House of the Silver Wedding, Pompeii, 160
House on the Massachusetts Coast, 143
House Study, 83
House, Ur of the Chaldees, 188
Housing Development, Pavia, Italy, 252
Huánuco Plan, Peru, 424
Humayun's Tomb, Delhi, India, 239, 425
Hurva Synagogue (project), Jerusalem, 184
Husser House, Chicago, Illinois, 397

IBM Research Center, La Guade, Var, France, 109
Ibrahim Rauza, Tomb of Sultan Ibrahim II, Bijapur, India, 187
Ideal Church Plan (da Vinci), 234, 236, 402, 409
Ideal Church Plan (Filarete), 392
Ideal City Plan (Martini), 310, 315
Ideal City Plan (Scamozzi), 90
Ideal City Plan (Sforzinda), 39, 94
Iglesia San Josemaría Escrivá, Alvaro Obregon, Mexico, 411
IIT Library Building (Project), Chicago, Illinois, 273
Il Redentore, Venice, 53
Imagination Art Pavilion, Zeewolde, The Netherlands, 147
Imperial Forums of Trajan, Rome, 391
Imperial Palace, Forbidden City, Beijing, China, 136
Imperial Palace, Kyoto, Japan, 21
Indian Institute of Management, Ahmedabad, India, 380
Institute of Technology, Otaniemi, Finland, 406
Interama, Project for Inter-American Community, Florida, 250
The Interlace, Singapore, 49
Internal Facade of a Basilica, 408
International Exposition of 1929, Barcelona, 167
Isaac Flagg House II, Berkeley, California, 399
Ise Shrine, 7
Isfahan (Persia) Civic Center Plan, 378, 425
Isfahan (Persia) Safavid Plan, 416
The Island Villa (Teatro Marittimo), Hadrian's Villa, Tivoli, Italy, 90, 220, 300
Itsukushima Temple, Hiroshima Prefecture, Japan, 388
Izumo Shrine, Shimane Prefecture, Japan, 102, 134

Jaipur city plan, India, 315
Jami Masjid, Ahmedabad, India, 436
Jami Masjid, Gulbarga, India, 431
Japanese Residence, 163
Japanese Traditional House, 217, 262, 320, 364, 367
Jasper Place Branch Library, Edmonton, Canada, 149
Jester House (Project), Palos Verdes, California, 445
Jewish Community Center, Trenton, New Jersey, 41, 421
John Deere & Company Building, Moline, Illinois, 108
John F. Kennedy Memorial, Dallas, Texas, 296
Johnson Wax Co. Building, Racine, Wisconsin, 104, 297

Kansai International Airport Terminal 1, Osaka Bay, Japan, 67
Kara Ahmed Pasha, Topkapi, 455
Karlsruhe, Germany, 310
Karuizawa House, Country Retreat, 263
Katsura Imperial Villa, Kyoto, Japan, 11, 47, 131, 158, 294, 433
Kaufmann Desert House, Palm Springs, California, 105, 257
Kaufmann House (Fallingwater), Pennsylvania, 207, 207, 267, 289
Kauwi Interpretive Center, Lonsdale, Australia, 410
Khasneh al Faroun, Petra, 69
Kilisse Mosque. *See* St. Theodore, Constantinople (Istanbul)
Kimball Art Museum, Fort Worth, Texas, 277
Kingo Housing Estate, Denmark, 171
Kneses Tifereth Israel Synagogue, Port Chester, New York, 298
Koshino House, Ashiya, Hyogo Prefecture, Japan, 414
Kresge College, Santa Cruz Campus, University of California, 287
Külliye of Beyazid II, Bursa, Turkey, 436

Laboratory Tower, Johnson Wax Building, Racine, Wisconsin, 104
La Roche-Jeanneret Houses, Paris, 71
Lawrence House, Sea Ranch, California, 21, 229
Legislative Assembly Building, Chandigarh, India, 293, 379, 407
Library in Rovaniemi Plan, Finland, 142
Library of Mount Angel, Benedictine College, Mount Angel, Oregon, 451
Library, Rovaniemi, Finland, 451
Library, Seinäjoki, Finland, 451
Library, Wolfsburg Cultural Center, Essen, Germany, 142
Lincoln Memorial, Washington, D. C., 7
Lingaraja Temple, Bhubaneshwar, India, 73
Lion's Column, Venice, 292
Lister County Courthouse, Solvesborg, Sweden, 91
Living Room, Samuel Freeman House, Los Angles, 201
Living Room, Villa Mjairea, Noormarkku, Finland, 201
Lloyd Lewis House, Libertyville, Illinois, 248
London City Hall, London, England, 191
Longhouse (Iroquois Confederacy dwelling), 246
Lord Derby's House, London, England, 248
Lowell Walter House, Quasqueton, Iowa, 406

Machu Picchu, Peru, 20
Maison de Force (Prison), Belgium, 255
The Mall, Washington, D. C., 7
Manabe Residence, Tezukayama, Osaka, Japan, 276
Manhattan city plan, New York City, 315
Marcus House (Project), Dallas, Texas, 249
Marin County Civic Center, San Rafael, California, 418
Massachusetts Institute of Technology Chapel, Cambridge, Massachusetts, 44
Maupertius, Project for Agricultural Lodge, 44

INDEX OF BUILDINGS

Meeting House, Salk Institute of Biological Studies (Project), La Jolla, California, 263
Memorial 9 (M9), Santiago, Chile, 410
Menhir, 10
Mercer's Castle (Fonthill), Doylestown, Pennsylvania, 266
Merchants' National Bank, Grinnell, Iowa, 295
Mihrimah Sultan, Istanbul, 455
Mihrimah Sultan, Üsküdar, 454
Mile-High Illinois Skyscraper Project, Chicago, Illinois, 79
Miletus Plan, Turkey, 420
Millowners' Association Building, Ahmedabad, India, 111, 163, 302, 453
Ministry of National Education and Public Health, Rio de Janeiro, Brazil, 217
Moabit Prison, Berlin, 255
Modern Art Museum, Caracas (Project), Venezuela, 40
Mojácar, Spain, 437
Monastery of St. Meletios on Mt. Kithairon, Greece, 122
Montfazier Plan, France, 404
Monticello, Virginia, 394
Mont St. Michel, France, 5, 161
Moore House, Orinda, California, 225
Morris Gift Shop, San Francisco, California, 295
Morris House (Project), Mount Kisco, New York, 267
Mortuary Temple of Queen Hatshepsut, Dêr el-Bahari, Thebes, 20, 306
Mortuary Temple of Rameses III, Medînet-Habu, 319, 394
Mosque of Sultan Hasan, Cairo, Egypt, 47, 379
Mosque of Tinmal, Morocco, 272
Murray House, Cambridge, Massachusetts, 91
Museum at Ahmedabad, India, 421
Museum for North Rhine–Westphalia (Project), Dusseldorf, Germany, 91
Museum of Endless Growth (Project), Philippeville, Algeria, 312
Museum of Western Art, Tokyo, Japan, 312, 453

Naigu, Ise Inner Shrine, Japan, 338
Nakagin Capsule Tower, Tokyo, Japan, 86
Nalanda Mahavihara, Bihar, India, 414
Nathaniel Russell House, Charleston, South Carolina, 395
National Assembly Building, Capitol Complex at Dacca, Bangladesh, 243
National Gallery of Art, Washington, D. C., 301
National Garden Show, Cologne, Germany, 145
National Museum of Roman Art, Mérida, Spain, 95
Neur Vahr Apartment Building, Bremen, Germany, 321
New Mummers Theater, Oklahoma City, Oklahoma, 259
Northern Palace at Masada, Israel, 389
North Indian Cella, 450
Notre Dame Du Haut, Ronchamp, France, 29, 32, 197, 206, 282
Notre Dame la Grande, Poitiers, France, 428
Nuraghe at Palmavera, Sardinia, 262
Nuremberg Charterhouse, 427

Obelisk of Luxor, Place de la Concorde, Paris, 10
Okusu Residence, Todoroki, Tokyo, 324
Olivetti Headquarters, Milton Keynes, England, 280
Olivetti Training School, Haslemere, England, 408
Olympic Arena, Tokyo, Japan, 436
Olympic Sculpture Park, Seattle Art Museum, Seattle, Washington, 125
Olympic Swimming Arena, Munich, Germany, 339
Olympic Velodrome, Athens, Greece, 64
One-Half House (Project), 231
One Shelley Street, Sydney, Australia, 192
O-torii, Toshogu Shrine, Japan, 292
The Oriental Theater, Milwaukee, Wisconsin, 299

Palace of Charles V, Granada, 409
Palace of Diocletian, Spalato, Yugoslavia, 395
Palace of King Minos, Knossos, Crete, 263
Palace of the Soviets (Competition), 398
Palacio Güell, Barcelona, Spain, 98
Palafolls Public Library, Palafolls, Spain, 125
Palazzo Antonini, Udine, Italy, 160, 320
Palazzo Chiericati, Vicenza, Italy, 358
Palazzo Farnese, Rome, 188, 348
Palazzo Garzadore (Project), Vincenza, Italy, 205
Palazzo Iseppo Porto, Vicenza, Italy, 359
Palazzo Medici-Ricardo, Florence, Italy, 107
Palazzo No. 52, 394
Palazzo Piccolomini, Pienza, Italy, 231
Palazzo Pietro Massimi, Rome, 400
Palazzo Thiene, Vicenza, Italy, 31
Palazzo Vecchio, Florence, 386
Palazzo Zuccari, Rome, 291
Palmach Museum of History, Tel Aviv, Israel, 50
The Pantheon, Rome, 119, 240, 298
Parco della Musica, Rome, Italy, 67
Paris (France) city plan, 316
Parish Center, Wolfsburg, Germany, 153
Parterre de Broderie, Palace of Versailles, France, 131
The Parthenon, Athens, 346, 348
Pavilion Design, 229
Pavilion of Commerce, Prague, 299
Pavilion of Supreme Harmony (Taihe Dian), Beijing, 135
Pavilion of the Academia, Hadrian's Villa, Tivoli, Italy, 300
Pazzi Chapel, Florence, Italy, 298
Pearl Mosque, Agra, India, 94
Pearson House (Project), 248
Pensiero Della Chiesa S. Carlo, (Project), 55
Peregrine Winery, Gibbston Valley, New Zealand, 148
Pergamon city plan, 382
Peristyle Courtyard House Plan, Greece, 424
Peyrissac Residence, Cherchell, Algeria, 23
Philharmonic Hall, Berlin, 47
Philip Exeter Academy Library, Exeter, New Hampshire, 427
Piazza del Campidoglio, Rome, 5, 182
Piazza del Campo, Siena, Italy, 158
Piazza della Signoria, Florence, 386
Piazza Maggiore, Sabbioneta, Italy, 31
Piazza of St. Peter, Rome, 158
Piazza San Marco, Venice, 22, 123, 292, 417
Pilgrimage Church, Vierzehnheiligen, Germany, 227
Place Royale, Paris, France, 424
Pompeii residential fabric, Italy, 435
Pope House, Salisbury, Connecticut, 311
Potala Palace, Lhasa, Tibet (China), 405
Poteries du Don, Le Fel, France, 48
Priene City, Turkey, 272, 315
Propylaea, Athens, 288
Pueblo Bonito, Chaco Canyon, USA, 378, 438
Pyramids of Cheops, Chephren, and Mykerinos at Giza, Egypt, 45

Qian Men, China, 285
Queen's College, Cambridge, England, 78

Rajarajeshwara Temple, Thanjavur, India, 264, 432
Ramp-in-a-Square, 453
Red Fort, Pearl Mosque, Agra, India, 94
Reims Cathedral, England, 373, 430
Residence in Morris County, New Jersey, 325
Residential Care Unit, Hokkaido, Japan, 443
Restaurant Los Manantiales, Xochimilco, Mexico, 63
Ritual Complex at Fengchu, Shaanxi Province, China, 393
Robert W. Evans House, Chicago, Illinois, 398
Robie House, Chicago, 26
Rock-cut churches of Lalibela, 139
Rockefeller Center Lower Plaza, New York, 141
Rock of Naqsh-i-Rustam, Iran, 294
Roman Camp, 314
Romano House, Kentfield, California, 249
Roman Theater, 39
Rome (Italy) city plan, 316
Rome (Italy) map, 121
Roq Housing Project, France, 441
Rosenbaum House, Florence, Alabama, 171
Rovaniemi City Library, Rovaniemi, Finland, 451
Rowhouses in Galena, Illinois, 302
Royal Crescent at Bath, England, 253
Runcorn New Town Housing, England, 77
Rüstem Pasha, Istanbul, 455

Sacred Enclosure, Ise Inner Shrine, Mie Prefecture, Japan, 186
Sacred Precinct of Athena, Pergamon, Asia Minor, 182
Safavid Isfahan Plan, Iran, 416
Salginatobel Bridge, Switzerland, 11
Salisbury Cathedral, England, 430
Salk Institute of Biological Studies (Project), California, 263
Salvation Army Hostel, Paris, 418
Samuel Freeman House, Los Angeles, California, 201, 452
San Lorenzo Maggiore, Milan, Italy, 234, 241
Sannen-zaka, Kyoto, 333
Santa Barbara Courthouse, California, 303
Sarabhai House, Ahmedabad, India, 178
Savannah Plan, Georgia, 404
Scala de Spagna (Spanish Steps), Rome, 20
Scamozzi's Library, Venice, 292
Scarborough College, Westhill, Ontario, 252, 309
Scheme for 3 libraries, 451
Schröder House, Utrecht, 27
Schwartz House, Two Rivers, Wisconsin, 339
Seagram Building, New York City, 13
Seattle Art Museum Olympic Sculpture Park, Seattle, Washington, 125
Seattle Public Library, Seattle, Washington, 190
Secretariat Building, UNESCO Headquarters, Place de Fontenoy, Paris, 81, 258
Şehzade, Istanbul, 454
Seinäjoki Public Library, Seinäjoki, Finland, 451
Seinäjoki Theater, Finland, 127
Selimiye, Edirne, 455
Selim Mosque, Edirne, Turkey, 10
Selwyn College, Cambridge, England, 167
Semizali Pasha, Babaeski, 455
Shanghai Astronomy Museum, Shanghai, China, 49
Sheffield University (Project), England, 247
Shodhan House, Ahmedabad, India, 26, 70, 275, 308
Shokin-Tei Pavilion, Katsura Imperial Villa, Kyoto, Japan, 158
Shrine of Apollo Delphinios, Miletus, 189
Shwezigon Pagoda, Pagan, Burma, 378, 426
Siedlung Halen, Switzerland, 179, 435
Sinan Pasha, Istanbul, 455
Sitting Area, Lawrence House, Sea Ranch, California, 21
Sketch of Oval Church by Borromini, 184
Skylighted Concourse, Olivetti Headquarters (Project), Milton Keynes, England, 280
Skyscraper by the Sea, Project for Algiers, 81
The Smitheum, 430
Snyderman House, Fort Wayne, Indiana, 276
Soane House, London, England, 265
Social Housing, Louviers, France, 442
Social Science Research Center, Berlin, Germany, 414
Sokollu Mehmet Pasha, Lüleburgaz, 455
Solarium of Condominium Unit 1, Sea Ranch, California, 17
Spanish Steps (Scala de Spagna), Rome, 20
SS. Sergio and Bacchus, Constantinople (Istanbul), Turkey, 241, 409
Staatsgalerie, Stuttgart, Germany, 93
St. Agostino, Rome, 166
St. Andrea del Quirinale, Rome, 300
St. Andrea, Mantua, Italy, 301
St. Andrew's Beach House, Victoria, Australia, 115
St. Andrews University, Scotland, 247, 258
St. Apollinare in Classe, Ravenna, Italy, 176
St. Carlo alle Quattro Fontane, Rome, 265
Step well at Abhaneri, India, 140
Stern House, Woodbridge, Connecticut, 319
St. Giorgio Maggiore, Venice, 293
St. Ivo della Sapienze, Rome, 237
St. Maria della Pace, Rome, 324
St. Maria Della Salute, Venice, 74
St. Maria Novella, Florence, Italy, 22, 356
St. Mark's Tower, Project, New York City, 94, 173
St. Mary Axe, London, United Kingdom, 193
Stoa of Attalus fronting the Agora in Athens, 15
Stockholm Public Library, 242
Stonehenge, England, 378
St. Pancras Station, London, England, 379
St. Peter, Plan for (First Version), Rome, 238
St. Peter, Plan for (Second Version), Rome, 227
St. Philibert, Tournus, France, 16
St. Pierre, Virminy-Vert, France, 55
St. Pietro in Montorio, Rome, 75, 347
St. Theodore, Constantinople (Istanbul), 447
Student Apartments, Selwyn College (Project), Cambridge, England, 167
St. Vitale, Ravenna, Italy, 299
Süleymaniye, Istanbul, 454, 455
Suleymaniye Mosque, Constantinople (Istanbul), 37
Suntop Homes, Ardmore, Pennsylvania, 173
Swiss Re Building. *See* 30 St. Mary Axe, London, United Kingdom
Sydney Opera House, Sydney, Australia, 448

Taj Mahal, Agra, India, 121, 159, 239
Taliesin West, near Phoenix, Arizona, 302
Taliesin West, near Scottsdale, Arizona, 95
Taos Pueblo, New Mexico, 84
Teatro Marittimo (The Island Villa), Hadrian's Villa, Tivoli, 90
Telo town square, Czechoslovakia, 415
Tempietto, St. Pietro in Montorio, Rome, 75, 347
Temple "B," Selinus, 184
Temple Mountain, Bakong Temple, Cambodia, 135
Temple of Amun at Karnak, Egypt, 378, 388
Temple of Athena Polias, Priene, 16
Temple of Horus at Edfu, 296
Temple of Jupiter Capitolinus, Rome, 134

INDEX OF BUILDINGS

Temple of Kailasnath at Ellora, near Aurangabad, India, 118
Temple of Nemesis, Rhamnus, 184
Temple of the Inscriptions, Palenque, Mexico, 439
Temple on the Ilissus, Athens, 184, 350
Tenerife Concert Hall, Canary Islands, Spain, 65
Tensile Structure, National Garden Show, Cologne, 145
Teotihuacan, City of the Gods, Mexico, 386
Tetrastyle Atrium, House of the Silver Wedding, Pompeii, 160
Theater at Epidauros, Greece, 140
Third Floor Plan, Centrosoyus Building, Moscow, 397
Tholos of Polycleitos, Epidauros, Greece, 5
Thomas Hardy House, Racine, Wisconsin, 452
Timgad Town Plan, North Africa, 420
Tjibaou Cultural Center, Nouméa, New Caledonia, 447
TOD's Omotesando Building, Tokyo, Japan, 192
Tokonoma (spiritual center), 217, 364
Tomb of Emperor Wan Li, China, 303
Tomb of I'timad-ud-daula, Agra, India, 159
Tomb of Jahangir, Lahore, 159
Tomb of Muntaz Mahal, Agra, India, 159
Torii (gateway), 388
Torii, Ise Shrine, Mie Prefecture, Japan, 7
Toshogu Shrine, Japan, 292, 306
Totsuka Country Club, Yokohama, Japan, 146
Town Center for Castrop-Rauxel, Germany, 250
Town Hall, Säynätsalo, Finland, 13, 189, 286
Town Hall, Seinäjoki, 408
Traditional House in Konya, Turkey, 171
Trulli Village, Alberobello, Italy, 84

Uffizi Palace, Florence, Italy, 22, 384, 386
Underground village, China, 141
UNESCO Headquarters, Paris, 81, 258
Unité d'Habitation, Firminy-Vert, France, 53, 362
Unité d'Habitation, Marseilles, France, 247, 363, 431
United States Capitol Building, Washington, D. C., 7
Unity Temple, Oak Park, Illinois, 396
University Art Museum, University of California–Berkeley, 311
University of Virginia, Charlottesville, Virginia, 185, 373

Vacation House, Sea Ranch, California, 83
Vadakkunnathan Temple, Trichur, India, 264
Valhalla, near Regensburg, Germany, 135
Valley Center House, San Diego, California, 97
Vegetation Forming L-shaped Windscreens, Japan, 170
Victorian Facades, 440
Vigo Sundt House, Madison, Wisconsin, 40
Villa Aldobrandini, Italy, 12
Villa at Carthage, Tunisia, 227
Villa at Garches, 71
Villa Barbaro, Maser, Italy, 284
Villa Capra (The Rotunda), Vicenza, Italy, 74, 239, 358
Villa Farnese, Caprarola, Italy, 238, 378, 385
Villa Foscari, Malcontenta, Italy, 349
Villa Garches, Vaucresson, France, 30, 37, 284, 349, 401
Village Project, 179, 246
Villa Hermosa, Spain, 437
Villa Hutheesing (Project), Ahmedabad, India, 289
Villa Madama, Rome, 391
Villa Mairea, Noormarkku, Finland, 201
Villa Romana del Casale, Piazza Armerina, Sicily, Italy, 426
Villa Savoye, Poissy, France, 453
Villa Thiene, Cicogna, Italy, 359
Villa Trissino at Meledo, 183, 404
Vincent Street Flats, London, 107
Vitruvian man, 334
Von Sternberg House, Los Angeles, California, 293

W.A. Glasner House, Glencoe, Illinois, 391
Walt Disney Concert Hall, Los Angeles, California, 65
Ward Willitts House, Highland Park, Illinois, 452
Washington D.C. city plan, 317
Washington Monument, Washington, D.C., 7
Wenling Museum, Wenling, China, 59
Westendinhelmi Housing, Espoo, Finland, 442
West Precinct, Horyu-Ji Temple, Nara Prefecture, Japan, 415
Willis, Faber & Dumas Headquarters, Ipswich, England, 190
Wingspread (Herbert F. Johnson House), Wisconsin, 256
Wolfsburg Cultural Center Library, Germany, 142
Woodland Chapel, Stockholm, Sweden, 341
Woodstock Street, Oxfordshire, England, 131
World Museum (Project), Geneva, Switzerland, 347
Wyntoon, Country Estate for the Hearst Family in Northern California, 266

Yahara Boat Club Project, Madison, Wisconsin, 55
Yeni-Kaplica (Thermal Bath), Bursa, Turkey, 262
Yingxian Timber Pagoda, China, 378
Yi Yuan (Garden of Contentment), Suzhou, China, 317
Yume-Dono, Eastern precinct of Horyu-Ji Temple, Nara, Japan, 75

Aalto, Alvar, 10, 13, 24, 25, 127, 142, 153, 172, 184, 185, 189, 201, 250, 252, 253, 286, 321, 406, 408, 419, 446, 449, 451
Abramovitz, Max, 141
Adam, Robert, 248
Adams, Maurice, 441
Alberti, Leon Battista, 14, 22, 301, 356, 357
Ando, Tadao, 276, 324, 414
Andrews, John, 252, 309
Anthemius of Tralles, 240
Architecture Workshop, 148
Arkitekter, Belatchew, 92
Asplund, Erik Gunnar, 341
Asplund, Gunnar, 91, 242
Atelier 5, 179, 435
Auer + Weber Associates, 411

Bach, Johann Sebastian, 412
Barker, Tom, 67
Barnes, Edward Larrabee, 309
Bates Smart, Architects, 115
Bauhaus Study, 232
Bawa, Geoffrey, 57
Behrens, Peter, 56
Bernini, Giovanni, 158, 300
Boffrand, Germain, 406
Borromini, Francesco, 55, 237, 265, 303, 440
Botta, Mario, 69
Boullée, Étienne-Louis, 5, 44, 153
Boyle, Richard (Lord Burlington), 229
Bramante, Donato, 75, 227, 238, 324, 347
Breuer, Marcel, 81, 109, 258
Brunelleschi, Filippo, 298
Buon, Bartolomeo, 400
Buon, Giovanni, 400
Burlington, Lord (Richard Boyle), 229
Busse, August, 255

Calatrava, Santiago, 64, 65
Callicrates, 346
Cambio, Arnolfo di, 386
Candela, Felix, 63
CCTN Architectural Design Company, 59
Charles Moore Associates, 319
Ciampi, Mario J., 311
COOP HIMMELB(l)au, 66
Correa, Charles, 275
Courtonne, Jean, 390

Daly, Genik Architects, 97
David Chipperfield Architects, 48, 191
da Vinci, Leonardo, 234, 236, 402, 409
Deborah Berke Partners, 322
De Florinier, Michel, 48
Della Porta, Giacomo, 12
Denti, Paolo, 124
Design Development Drawings, 95
Dick and Bauer, 299
Dieste, Eladio, 398
Diotisalvi, 5
Dub Architects, 149

Eero Saarinen and Associates, 44, 108
Eisenman, Peter, 95
El Habbak, Ihab, 92
Emre Arolat Architects (EAA), 124
Ennead Architects, 49
Erick van Egeraat Associated Architects, 97
Erlach, Fischer von, 229
Esherick Homsey Dodge & Davis, 249
Esherick, Joseph, 17

Filarete, Antonio, 39, 94, 392
Fisher, Frederick, 231
Fitzpatrick + Partners, 192
Foster + Partners, 190, 191, 193
Foster, Norman, 50
Francois, Edouard, 442
Frank O. Gehry & Partners, 65
Fujimoto, Sou, 443

Garnier, Charles, 330
Gaudi, Antonio, 98
GEC Architecture, 64
Gehry, Frank O., 65, 259
Ghiyas, Mirak Mirza, 239, 425
Giorgi, Francesco, 356
Gluck, Peter L., 309
Goodwin, E. W., 441
Gowan, James, 83, 167
Graves, Michael, 45, 70, 276
Greene & Greene, 267
Griffin, Walter Burley, 259
Grimshaw Architects & Anthony Hunt Associates, 269
Gutbrod, Rolf, 422
Gwathmey, Charles, 53, 70
Gwathmey Siegel & Associates, 53, 70

Hammel, Green & Abrahamson, 137
Harrison, Wallace K., 141
Haviland, John, 311
Hawksmoor, Nicholas, 78
Hearst, William Randolph, 50
Hecker, Zvi, 50
Hejduk, John, 12, 231, 251
Helen & Hard Architects with SAAHA Architects, 96
Henning Larsen Architects + Tomoon Architects, 66
Herrmann, Heinrich, 255
Hertzberger, Herman, 50, 274
Hoesli, Bernhard, 95
Hughes Condon Marier Architects, 149

Ictinus, 346
Isidorus of Miletus, 240
Isozaki, Arata, 86, 108

Jefferson, Thomas, 185, 373, 394
JMA Architects, 124
Johansen, John M., 243, 259, 311
Johnson, Philip, 13, 25, 131, 148, 166, 225, 277, 286, 296, 298, 321

Kahler, Heine, 300
Kahn, Albert, 77
Kahn, Louis, 41, 109, 183, 184, 243, 250, 263, 267, 274, 277, 380, 409, 418, 421, 427, 434
Kallmann, McKinnell & Knowles, 123
Kapeller, Christoph, 92
Kappe, Raymond, 87
Kent, William, 229
Klenze, Leon von, 135
Konieczny, Robert, 150
Koolhaas, Rem, 51, 60
Kotera, Jan, 299
Kurokawa, Kisho, 86, 263

LAB Architecture Studio, 115
Lacombe, Jacques, 48
Latrobe, Benjamin Henry, 185
Le Corbusier, 23, 26, 29, 30, 32, 37, 42, 53, 55, 70, 71, 81, 90, 111, 137, 149, 153, 162, 163, 178, 197, 199, 206, 227, 247, 274, 275, 282, 285, 286, 289, 292, 293, 297,

INDEX OF DESIGNERS

Le Corbusier (*continued*) 302, 308, 312, 314, 347, 348, 349, 360, 361, 362, 363, 379, 398, 401, 407, 419, 421, 423, 431, 441, 453
Ledoux, Claude-Nicolas, 48
L'Enfant, Pierre, 317
Le Nôtre, André, 131
Le Pautre, Antoine, 392
Libeskind, Daniel, 61
Longhena, Baldassare, 74
Lutyens, Sir Edwin, 107, 405

Machuca, Pedro, 409
Mackintosh, Charles Rennie, 203
Maderno, Carlo, 379
Maillart, Robert, 11
Malfaison and Kluchman, 255
Mario J. Ciampi and Associates, 311
Marja-Ritta Norri Architects, 442
Martini, Francesco di Giorgi, 310, 315
Matsaetsi, Oton, 434
Maybeck, Bernard, 266, 399
May, E. J., 441
Meier, Richard, 12, 107, 177, 307, 331
Mendelsohn, Eric, 104
Mengoni, Giuseppe, 176
Mercer, Henry, 266
Michelangelo, 5, 379
Michelozzi, 107
Mies van der Rohe, Ludwig, 13, 21, 23, 24, 47, 103, 136, 147, 167, 173, 205, 273, 320, 339
Miralles, Enric, 125
Miralles Tagliabue EMBT, 125
MLTW/Moore and Turnbull, 229, 287, 300, 307. *See also* Moore, Lyndon, Turnbull, Whitaker (MLTW)
Mnesicles, 11
Moneo, Rafael, 95
Moore, Charles, 91, 225
Mooser, William, 303
Murata, Misako, 268

Nervi, Pier Luigi, 25
Neski, Barbara, 69
Neski, Julian, 69
Neumann, Balthasar, 227
Neutra, Richard, 105, 257, 293
Niemeyer, Oscar, 40
Nikken Sekkei Ltd and Ove Arup & Partners, 67
Nolli, Giambattista, 121

Oglethorpe, James, 404
OMA, 49, 51, 60, 190
Otto, Fred, 339
Otto, Frei, 145, 422
Owen, Christopher, 251

Palladio, Andrea, 15, 31, 53, 74, 103, 160, 183, 205, 239, 284, 293, 320, 349, 357, 358, 359, 394, 404
Paxton, Sir Joseph, 273
Peabody & Stearns, 83
Pei, I. M., 102, 301
Peruzzi, Baldassare, 227, 400
Petit, Antoine, 255
Piano, Renzo, 67, 447
Pietrasanta, Giacomo da, 166
Polycleitos, 140
Pont, Henri Maclaine, 152
Pythius, 16

Renzo Piano Building Workshop, 67
Rice, Peter, 67
Rietveld, Gerrit Thomas, 27
Rojkind Arquitectos, 59
Rosselino, Bernardo, 231
Rural Studio, Auburn University, 147

Saarinen, Eero, 44, 108
Safdie, Moshe, 85
Sanctis, Francesco de, 20
Sandal, Malik, 187
Sangallo, Antonio da (the Younger), 188, 348
Sanzio, Raphael, 391
Scamozzi, Vincenzo, 90, 292, 293
Scharoun, Hans, 47
Scheeren, Ole, 49, 51
Schinkel, Karl Friedrich, 15
Scott, George Gilbert, 379
Sean Godsell Architects, 115
Segal, Rafi, 50
Senmut, 20, 306
Serlio, Sebastiano, 237, 357
Shaw, Norman, 441
Shreve, Lamb, and Harmon, 378
Shukhov, Vladimir, 63
Sinan, Mimar, 10, 37, 454, 457
Sitte, Camillo, 287
Snyder, Jerry, 412
Soane, Sir John, 265
SOM, 273
Sordo Madaleno Arquitectos, 411
Specchi, Alessandro, 20
Stirling, James, 77, 83, 91, 93, 167, 172, 179, 182, 246, 247, 258, 280, 408, 414
Stromeyer, Peter, 145
Stubbins, Hugh, 142
Sullivan, Louis, 79, 295

Tagliabue, Benedetta, 125
Takenaka Corporation, 61
Tange, Kenzo, 146, 436
Thornton, John T., 185
Toyo Ito and Associates, 192

Utzon, Jørn, 171, 252, 448

Van Doesburg, Theo, 105, 205
Van Esteren, Cornels, 105, 205
van Eyck, Aldo, 178
van Zuuk, René, 147
Vasari, Giorgio, 22, 386
Vector Architects, 151
Venturi and Short, 264, 296
Venturi, Robert, 248
Vignola, Giacomo da, 238, 378, 385
Vitruvius, 39, 160, 350
Viviani, Gonzalo Mardones, 410
Volwahsen, Andras, 159

Ware, William R., 322, 350
Weiss/Manfredi Architecture/Landscape/Urbanism, 125
Wilford, Michael, 91, 93, 280
Wilhelmson, Anders, 253
Woodhead, 410
Wood, John, Jr., 253
Wood, John, Sr., 253
Wright, Frank Lloyd, 26, 27, 40, 47, 55, 74, 79, 94, 95, 104, 171, 173, 201, 207, 242, 248, 249, 256, 267, 269, 289, 295, 297, 302, 313, 339, 389, 391, 396, 397, 398, 406, 418, 445, 452

Zuccari, Federico, 291

1:2 modularity, 365
3D modeling, 193
3D printing, 193

acoustics, 21, 25, 140
additive form, 71, 72–73
additive transformation, 52, 53
adjacency, 228
adjacent spaces, 223, 228–229
Alberti, Leon Battista, 14, 22, 301, 356, 357
allée, 175
Allen, Gerald, 221
"all is number" concept, 344
American Institute of Steel Construction, 340
amphiprostyle, 430
Amphiprostyle temple, 430
amphitheater, 140, 172
anthropometry, 343, 368–370
approach, 281, 282–289. *See also* entrance
araeostyle order, 354
arbor, 175
arcade, 176, 187, 415, 454
architectural principles,, 381–455
arenas, 140
arithmetic means, 357
arithmetic proportion, 343
Armenian church typology, 433
Arnheim, Rudolf, 381
articulation of form, 98–99
art nouveau, 295
asymmetrical curved surfaces, 65
asymmetrical forms, 27, 46
atrium space, 122, 186, 188
axial symmetry, 265
axis, 6–7, 12, 42, 54, 56, 62, 123, 158, 174, 260, 383, 384–391, 412

background, 120–121, 126
Bacon, Edmund N., 33
barrel vaults, 64
base plane, 19, 129, 130–131
bay window, 203, 216
beams, 338, 428
bearing-wall constructions, 190
bearing walls, 23, 175, 178–179, 339. *See also* load transfer
bending stress, 338
bermed ground plane, 20
bicycle, 30
bilateral symmetry, 392, 393
boundaries, 89, 138, 144
brick, 337, 339, 340, 373
brise-soleil. *See* eggcrates
building material, 337
building scale, 186. *See also* proportion; scale
building site. *See* site
buoyancy-driven ventilation, 218

CAD software, 193
car, 304
carved ground plane, 20
ceiling plane, 19, 23, 25, 36, 152
centered entrance, 195
centered opening, 195, 196
centralized form, 7, 73, 74–75
centralized organizations, 233, 234–243, 260
centralized space, 385
characteristic ratio, 342
China, 364
circle, 5, 38–39
circle and square, 88, 90–93
circular form, 90
circular space, 91
circular stair, 327
circulation, 279–334. *See also* approach; entrance; movement; path configuration
circulation elements, 281
circulation: movement through space, 280
circulation path, 177
circulation space, 177, 281, 322–334
circulation system, 280, 282
classical orders, 343, 350–355
climatic elements, 19, 22, 26, 154
cloister, 188
clustered form, 73, 82–85
clustered organization, 82, 233, 260–269
clustered spaces, 260
colonnade, 15, 161, 176, 333, 430
color, 34, 106, 107, 165, 174, 207, 209
column, 5, 10, 14, 156, 157, 162, 164, 338, 339, 364, 365, 428
columnar elements, 5, 7
column grid, 161, 162–163
column spacing, 365
common brick, 340
composite order, 351
composite path, 305
computer aided design software, 193
concrete block, 340, 373
concrete slabs, 162
concrete wall, 339
cones, 42, 43, 46, 75
configuration of path, 281, 304–317
contained space, 224
continuity, 24, 68, 99, 100, 101, 104, 139
contrast, 138, 224
contrasting rhythms, 438
cool regions, 56
Corinthian order, 351, 352
corner openings, 198
corner(s), 101–105, 156, 157, 159, 160, 169. *See also* edges and corners
corridors, 219, 281
courtyard, 123, 151, 168
cross ventilation, 219
crown hall, 339
cube, 47, 54–55, 56
cubes, 42, 43, 46, 54
cubic compositions, 71
cubic volumes, 87
cumulative composition, 71
curved form of linear organizations, 245
curved surfaces, 62, 63, 64
cylinder, 5, 42, 46, 75
cylindrical space, 91
cylindrical surfaces, 62

datum, 383, 412–427
daylight, 208–210. *See also* light
deep-set opening, 195, 196
degree of enclosure, 204–205
density, 21
depressed base plane, 129, 138–143
depth-to-span ratio, 338
de Stijl school, 27
detail characteristics, 429
diagrid structures, 63, 192–193
diastyle order, 354
digital modeling, 44, 173
dimension. *See* proportion; scale
dimensional transformation, 52, 53, 54–57
dipteral, 398
distyle in Antis, 430
diversity, 382
dome, 64, 193, 339
dominant space, 263–264
doors, 340, 428

INDEX OF SUBJECT MATTER

doorway, 24, 373
Doric order, 351, 352
double-curved surface geometry, 191
dynamic facades, 112

edge definition, 101, 103, 123, 130, 132, 133, 144, 155, 157, 161, 164, 165, 168, 196, 198
edge opening, 204
edges and corners, 100, 157. *See also* corner(s)
edge-to-edge contact, 72
eggcrates, 110, 111
elevated base plane, 129, 132–137
elevated floor plane, 21, 137
elevated ground plane, 20, 135
elevation, 29
enclosed circulation space, 323
enclosed spatial field, 190–193
enclosure, 127, 165, 190–193, 204–205
energy generating glazing or cladding, 113
entablature, 15, 350
entrance, 69, 183, 235, 281, 290–303. *See also* approach
equilibrium, 9, 40, 41
ergonomics, 369
Euclid, 342
Eustyle order, 354
exoskeletal framework, 192
exterior wall planes, 22
exterior walls, 190
eye level, 165

facades, 112, 293, 296
face-to-face contact, 72
Fibonacci Series, 344
field of space. *See* spatial field
figure, 36, 120, 121
figure-ground relationship, 102121
fire protection, 179
Five Points of the New Architecture, 162
floor and roof slabs, 339
flooring material, 21
floor plane, 19, 21, 130, 133, 136, 137, 139, 142, 144, 211
floor slab, 349
flush entrance, 291
forecourt, 183, 385, 454
form, 28, 30–31, 33–115, 382, 444
formal collisions of geometry, 88–89
form and space, 117–220, 382–384, 392, 402, 428, 444, 456
four planes: closure, 155, 186–189
four planes: enclosure, 190–193
frame structures, 190
frame with adjacent spaces, 87
free façade, 162
free plan, 162
French doors, 325
frontal approach, 283

galleries, 281
gallery space, 187
gateways, 7, 284, 385
geometric means, 357
geometric proportion, 343. *See also* proportion
geometric transformation, 52, 58–67
geometry, 38, 62, 63, 86, 88, 138, 190, 191, 219, 262, 339, 356, 403
gestalt psychology, 38
glare, 208
Golden Rectangle, 345–346
Golden Section, 343, 344–347, 348, 360, 444
Gothic church, 356
gravity, force of, 9, 21, 337
Greek/Greece (ancient), 344, 350, 356, 360
Greek musical system, 356
Greek shrine, 188
Greek temple, 184
greenhouse space, 201
green roof, 151
grid form, 73, 86–87, 271
grid of columns, 161, 162–163, 377
grid organization, 233, 270–277
grid path, 305, 314–315
gridshell structures, 63, 191
ground plane, 9, 19, 20, 37, 130, 141, 150
grouped opening, 195
grove, 159

halls, 281
harmonic means, 357
harmonic proportion, 343. *See also* proportion
heating, 112
hedges, 175
height, 165, 354, 365
hierarchy, 250, 383, 396, 402–411
horizon, 9
horizontal elements defining space, 129–153
horizontal line, 9
horizontal louvers, 110
horizontal opening, 195, 200, 213
horizontal overhangs, 110
horizontal plane, 27, 154
horizontal planes, 154
horizontal rhythms, 438
hot-arid regions, 57
hot-humid regions, 57
housing complex layouts, 443
human scale, 361, 362, 373, 374–377. *See also* proportion; scale
hyperbolas, 62
hyperbolic paraboloids, 62

Inaka-ma method, 365
intercolumniation, 350, 354
interior design elements, 217
interior openings, 216
interior wall planes, 24, 175
interlocking spaces, 223, 226–227
interlocking volumes, 72
intermediate space, 230
International Metric System, 371
intersection, 304
Ionic order, 350, 351, 352
irregular forms, 46–51, 66
irregular prism, 58
Italian palazzo, 31, 188

Japanese farmers, 170
joists, 340

Kampen, Holland, 78
ken (measurement unit), 343, 364–367
kinetic facades. *See* dynamic facades
Klee, Paul, 1
Kyo-ma method, 365

landings, 326, 328
landscapes, 124–125
Lao-tzu, 117
Le Corbusier, 42, 71, 111, 162, 217, 344, 347, 348, 349, 360–362, 457
length, 8–9
light, 42, 152, 194, 198, 206–211. *See also* openings; skylight opening; windows
light membranes, 162
line, 1, 3, 8–9, 412, 413

linear elements, 10–13, 15–17
linear form, 73, 76–79
linear organization, 79, 233, 244–253
linear path, 277, 279–281
linear path, 305, 307–309
linear sequences and expressing movement, hierarchy to, 250
linear sequences of rooms, 248–249
linear sequences of spaces, 247–248
line to plane, 14
load distribution, 192
load paths, 192
load transfer, 145, 147. *See also* bearing walls
Louis Phillipe (king of France), 10
Louis XIV (king of France), 316
louvers, 110
L-shaped plane, 23, 68, 155, 168, 169–173
L-shaped stair, 327
Lucca, Italy, 287
Lyndon, Donlyn, 221

manufactured proportions, 340–341
map of Rome, 121
marquees, 299
masonry units, 307
masonry vault, 145
masonry wall, 339
mass, 18, 19, 28, 29, 37
material proportion, 337
mathematical proportion, 344, 349, 356
mausoleum structure, 159
meaning in architecture, 456–457
means, 343, 348, 357
measurement units, 350, 371
mechanical scale, 372
membrane, 339
minarets, 159
Modena, Italy, 287
modular building unit, 340
modular materials, 373
Modulor system, 343, 360–363
Mogul mausoleum structure, 159
Mohamed Ali (viceroy of Egypt), 10
monastery, 188
Moore, Charles, 221, 279
movement, 77, 235, 251, 280. *See also* circulation
multiple openings, 196
Muntaz Mahal, 121, 159

natural light. *See* daylight
natural ventilation, 218
Nefertiti (queen of Egypt), 36
network path, 305, 316–317
niche, 185
non-load bearing partitions, 162

obelisk, 5, 10, 156
oblique approach, 283
oblique line, 9
oblique prisms, 58
off-center entrance, 291
off-center opening, 195, 196
off-center point, 4
one side open circulation space, 323
open circulation space, 325
openings, 202, 204,, 212, 295. *See also* doorway; light; skylight opening; windows
openings at corners, 105, 198–199
openings between planes, 200–201
openings in space-defining elements, 194–195
openings within planes, 196–197
opposites, unity of, 120–127
optical patterns, 100, 106
ordering principles, 382–383
Orders, 350, 382
organization, 221–278
orientation, 35
orthographic plans, 29
outdoor space, 20, 172, 181
overhead plane, 19, 129, 144–153

Palladian villa, 349
parabolas, 62
paraboloids, 62
parallel bearing walls, 179
parallel lines, 14, 270
parallel planes, 155, 175–179
parallel vertical planes, 174, 175, 178
pass by spaces, 318
pass through spaces, 318
path configuration, 281, 291, 304–317
path-space relationships, 281, 318–321
pattern, 18, 99, 107, 110, 152, 165, 260. *See also* grid organization; repetition; rhythm
pavilion structure, 146
pedestrians, 304
perception, 9, 14, 18, 34, 36, 100, 106, 118, 120, 165, 202–204, 211, 372–373, 378
perforated metal screens, 112
pergola, 17, 175
peripteral temple, 430
perpendicular axis, 6
perpendicular space zones, 23
Perugia, Italy, 287
pilasters, 14
placement, 403
plan and section, 29, 446
planar elements, 21–27
plane, 1, 3, 14, 15–17, 18–19, 105, 129–153, 195, 413
plane of entry, 7, 76, 165
plant-based technologies, 113
Plato, 356
plywood, 340
point, 1, 3, 4, 456. *See also* two points
point elements, 5
points in space, 385
polygons, 38
polyhedron, 43, 58
Polymer Dispersed Liquid Crystal technology (PDLC technology), 113
porches, 299
portals, 284
porticos, 299
position, 35
primary elements, 1–32
primary shapes, 38, 42
primary solids, 42–45, 68
principal façade, 166
principles, 381–455
prism, 58
prismatic forms, 58, 59, 60, 62
privacy, 154, 177, 212
progression, 181, 344, 356
projected entrance, 270, 291
promenade, 175
proportion, 165, 335–380. *See also* scale
proportioning systems, 342–343
prostyle temple, 430
pseudodipteral temple, 430
pycnostyle order, 354
pyramids, 42, 43, 46, 54
Pythagoras, 356, 357
Pythagorean creed, 356

qualities of architectural space, 202–203

INDEX OF SUBJECT MATTER

radial form, 73, 80–81
radial organization, 233, 254–259
radial path, 305, 310–311
radial symmetry, 392, 393
ramp, 133, 286, 302, 305, 308, 322
ramped ground plane, 141
Rasmussen, Steen Eiler, 335
ratio, 341, 342
rational forms, 190
recessed entrance, 69, 183, 291
rectangle, 41, 58, 342, 345, 348
rectangular column, 164
regular forms, 46–51
regularity, 68, 100
regular prisms, 58
regular space, 385
regulating line, 348–349
reinforced concrete construction, 162
Renaissance architects, 344, 356
Renaissance façade, 356
Renaissance theories of proportion, 343, 356–359
repetition, 9, 77, 429–449
repetitive, cellular spaces, 260
residential architecture, 171, 364
residual spaces, 224
responsive electrochromic glass and glazing, 113
rhythm, 110, 161, 326, 383, 428. *See also* repetition
right prisms, 58
Rome (ancient), 10, 119, 166, 240, 298, 348, 373, 379, 391, 395
Rome, map of, 121
roof plane, 19, 23, 25–26, 147, 148
roof slab, 26, 162, 339, 349
room height, 357, 375
rooms, 24, 357
room scale, 126, 143, 194
room shape and size, 357, 372, 375
rotated grid, 88, 94–97
rotation, 41
rotational surfaces, 62
round column, 164
rounded corners, 104
Rowe, Colin, 349
ruled surfaces, 62

saddle surfaces, 63
Salzburg, Austria, 287
scalar comparison, 378–380
scale, 101, 106, 122, 133, 139, 161, 165, 185, 194, 211, 293, 304, 322, 335–380, 371. *See also* human scale; proportion
scale, 335–380, 371
section, 29, 347, 446
segmented form of linear organizations, 245
semiotics, 456
Serlio, Sebastiano, 237, 357
shading devices, 110
Shah Jahan, 121
shaku (measurement unit), 364–365
shape, 18, 19, 34, 36–37, 403, 429
sheathing material, 340
shell structure, 63
Shukhov, Vladimir, 63
Siena, Italy, 287
sightlines, 140
simple geometric forms, 68
single vertical plane, 155, 164–167
site, 20, 140, 171, 244
site adaptation, 249–250, 252–253, 266
site slope, 179
Sixtus V (pope of Rome), 316
size, 34, 106, 120, 196, 211–212, 244, 260, 270, 338, 340, 368, 372, 376, 403, 429
skeletal structural system, 271
skylight opening, 195, 198, 200, 208, 212
slanted louvers, 110
smart facades, 112
The Smitheum, 430
solar shading devices, 110
solid masses, 46
solids, primary, 42–45
sound. *See* acoustics
space-path relationship, 290–293
space, 18–19, 23, 24, 28, 29, 37, 53, 79, 244, 247, 253. *See also* form and space
space and form, 117–220
spaces linked by a common space, 197, 204–205
spaces linked by common space, 223, 230–231
spaces organized around dominant space, 263
spaces organized by axial symmetries, 265
spaces organized by geometric pattern, 267–268
spaces organized by geometry, 262
spaces organized by site conditions, 266
spaces organized within spatial field, 264
space within space, 223, 224–225
spatial continuity, 133, 139, 161, 180, 224, 225, 228
spatial field, 174–175, 180, 182, 186
spatial field organization, 264
spatial organizations, 232–233
spatial relationships, 223–232
spatial tension, 72
spatial voids, 46, 121, 168
spatial volumes, 69
sphere, 5, 42, 46, 54, 75
spiral approach, 283
spiral path, 283, 305, 312–313
spiral repetition, 444
spiral stair, 327
square, 38, 41, 128, 181, 232, 341, 357
square and circle, 88, 90–93
square column, 164
square grid, 86
stability, 9, 40, 191
stack ventilation, 218
staircase, 322, 330
stairs, 133, 322, 326–334, 373
stairways, 281, 326–334, 374
standard gothic plan and section, 347
steel, 337, 339, 340
steel joist, 145
stepped floor plane, 21
stepped ground plane, 20, 21, 139
steps, 302
stone, 337
straight-run stair, 327
Strasbourg, France, 287
street space, 175
structural elements, 338
structural frame, 87
structural glass facades, 191
structural members, 147
structural proportions, 338–339
subtractive form, 68–71
subtractive transformation, 52, 53
sun-path diagram, 207
sunlight. *See* daylight
sunroom, 201
surface, 42
surface articulation, 106–115, 130, 186
surface color, 18, 106, 165
Suspended Particle Devices (SPD), 113
symmetrical curved surfaces, 64, 65
symmetrical planes, 174

symmetry, 6, 12, 383, 392–401
systyle order, 354

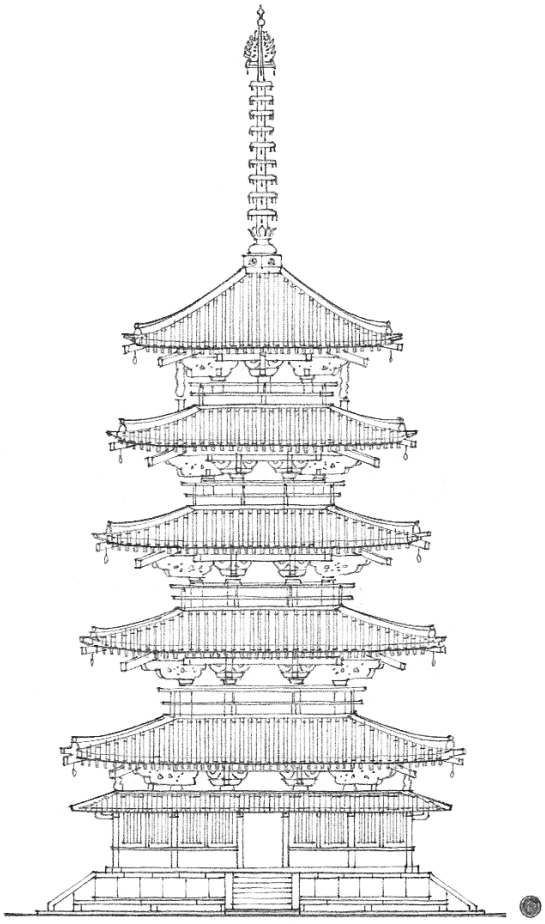
temperate regions, 56
temple classification, 354
temples, 184
tensile structure, 145
termination in space, 318
terraced floor plane, 21
terraced ground plane, 20, 139
texture, 2, 18, 19, 21, 27, 33, 34, 99, 106, 107, 152, 165, 202, 207
theories of proportion, 343
thermally reactive panels, 112
Thermochromic glass, 113
thickness, 9, 204, 335
three-dimensional form, 109, 128, 283, 330
three-dimensional grid, 73, 270, 271
three-dimensional space, 2, 12
three-dimensional volume, 2, 18–19, 28, 164
three-quarter opening, 195
tokonoma (picture recess), 364
tonal distribution, 210
tone, 130
topography, 20, 76, 89, 140, 175, 389
tower, 5, 10, 156
transformation, 52–53, 383, 450–455
translational surfaces, 62
translucent insulation products, 113
trees, 159, 175, 176
trees, mimicking, 192
trellises, 17
triangle, 38, 40
triple-glazed windows, 112
truncated triangular prism, 58
truss, 145, 191
T-shaped plane, 23
Tuscan order, 351, 352, 355
two points, 6–7, 12. *See also* point
two side open circulation space, 323

unity of opposites, 120–127
uplifting, 66
urban scale, 122, 372
urban space, 22, 122, 158, 182, 287
U.S. Customary System, 371
U-shaped plane, 155, 180–185
U-shaped stair, 327

vault, 145, 191, 339
vaulted staircase, 322
vegetated roof. *See* green roof
ventilation, 218–219
Venturi, Robert, 248, 264
vernacular architecture, 84
Verona, Italy, 287
vertical elements defining space, 154–193
vertical line, 9
vertical linear elements, 10, 144, 155, 156–163
vertical louvers, 110
vertical opening, 195, 200, 213
vertical plane, 27, 164–167, 385
vertical rhythms, 438
vertical slab, 53
vertical sunshading fins, 111
vertical wall plane, 23
view, 212–217
Vignola, Giacomo da, 350
Villa Foscari (subject), 335
visual continuity, 133, 161, 165, 180, 224, 225, 228
visual field, 4, 35, 73, 120, 154
visual inertia, 35
visual scale, 372–373
visual tension, 4
visual weight, 13, 18, 34, 106, 107, 165
Vitruvius, 350, 354, 430
void. *See* spatial voids
volume, 3, 17, 18, 28–29, 157, 165, 413
volumetric elements, 30–32
Volwahsen, Andras, 159

wall, 14, 175, 178. *See also* bearing walls
wall plane, 19, 22, 23, 24, 156, 178, 190, 200
wheel, 117
wind-induced ventilation, 218
window openings, 218
windows, 24, 194, 208, 210, 212, 216, 219, 340, 428. *See also* openings; skylight opening
window unit, 340
window-wall opening, 195, 201
windscreens, 170
wood, 337, 339, 340
wood truss, 145

Yarbus, Alfred L., 36
Yudell, Robert, 279



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